JAN 3 1920

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CVIII.—No. 2813.] *LONDON: FRIDAY, NOVEMBER 28, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE...9d. BY INLAND POST ... 11d.

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(Branch of Agricultural & General Engineers, Ltd.)
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STEAM CULTIVATING MACHINERY.

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AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

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See Illustrated Advertisement Page 131, Nov. 14.

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Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
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See page 17, Nov. 21. 7263

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Specification and Workmanship equal to Main Line Locomotives.
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W. H. SPENCER & CO., HITCHIN, HERTS.
See page 15, Nov. 21. 7454

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MEAN 7184
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Henry Wells Oil Co.,
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Tubes and Fittings.
6920
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HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement page 105.

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CARDIFF WAREHOUSE—123, BUTE ST.
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See Advertisement page 28. 7266

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See Illus. Advt. last week, page 15. 7077

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Head, Wrightson & Co.,
LIMITED.
See Advertisement page 91, Nov. 21. 8402

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 7280
See Full Page Advt., page 96, Nov. 14.

Taylor & Challen
Presses.
8198
TAYLOR & CHALLEN, LD., Engineers, BIRMINGHAM
See Full Page Advertisement, NOV. 14.

Steel Castings.
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Electric Transporters.
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See Pulleys Leaflet 7369
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For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
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The National Foremen's ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.

(Registered under the Trade Union Act.)

An Association specially formed to look after the interests of Foremen on their Supervisory Capacity. A 830

All communications to— H. W. RHID, General Secretary. Head Offices— 91, High Holborn London, W.C. 1.

IN PARLIAMENT—SESSION 1920.

Civil Engineers (Registration)

Extension of Charters and powers and objects of Institution of Civil Engineers: Registration of Civil Engineers: Rights to, Qualifications for, and Tribunal to determine certain claims to Registration. Examinations: Registration and examination fees: Entries and removal of names on and from and correction of register: Publication of register and copies evidence in certain cases: Attempts to register falsely: Prohibition of use of name title &c. of civil engineer and giving of certificates and recovery of charges by unregistered persons: Repeal and amendment of Charters Acts &c.

Notice is hereby given that application is intended to be made to Parliament in the ensuing Session by the Institution of Civil Engineers (hereinafter called "the Institution") for an ACT for the following or some of the following purposes (that is to say):—

1. To amend the Royal Charter or Letters Patent of the Institution dated the 3rd day of June in the year 9 Geo. IV. and the Supplemental Charters or Letters Patent dated the 3rd day of August 1889 and the 20th day of March 1896 and to confer further powers on the Institution.

2. To empower the Institution or the Council of the Institution (hereinafter called "the Council") to establish and keep and revise a register of civil engineers, to prescribe or make provision as to the persons who shall be entitled to be registered in such register and to enable the Institution or the Council to prescribe the qualifications and to hold examinations for the purpose of enabling persons to qualify for registration.

3. To make provision for the admission to the register of persons having such qualifications as the Institution or the Council shall from time to time declare or as the intended Act may prescribe or provide for and also for the admission thereto of other persons or certain other persons who at such date and for such period or at such date or for such period as may be prescribed or provided for by or under the intended Act may be or have been practising or engaged in the profession of civil engineer or as civil engineering assistants or otherwise or in either or both of such manners or for the admission to the register of such other persons as may be specified or provided for by or under the intended Act, to make provision for the refusal of admission to the register and the removal of names therefrom in certain cases.

4. To constitute and establish a tribunal or body for the purpose of hearing and determining claims by some or any of the before-mentioned persons for admission to the register and if thought fit for other purposes of the intended Act and to declare and provide for the nomination or appointment of members of such tribunal their powers rights duties clerks servants, expenses and procedure.

5. To provide for the proper keeping of the said register, the entry, amendment, and removal of names and qualifications and other particulars thereon, to provide for or require publication of the register or copies thereof, and to make the same when duly published or certified as the intended Act may require or provide for evidence of registration or non-registration of any person under the intended Act and of all or any other particulars appearing in such register or copies.

6. To enable the Institution to provide for the appointment or removal of a registrar and other officers and servants for and to make any other convenient provision for carrying out the purposes of the intended Act and to provide for the cost and expense of carrying out the same, and the remuneration, salaries or other benefits of such officers and servants.

7. To provide for the payment of fees in respect of any such examinations or such registration, to prohibit subject to penalties the obtaining or attempting to obtain registration by false or fraudulent representation, to prohibit or limit the use of the name or title of civil engineer by persons not registered under the intended Act or the use of any name title addition or description implying that any such persons are so registered, to prohibit registered persons practising or being in partnership with unregistered persons and to prohibit or limit the giving of certificates required to be given by civil engineers or the recovery of fees for professional services in civil engineering by persons not so registered.

8. To extend the powers of the Institution under the before mentioned Charters or any of them, to make bye-laws and regulations and to empower the Institution to make bye-laws and regulations for the purposes or for the better carrying into effect of the objects of the intended Act.

9. To repeal vary extend or amend all or any rights privileges powers provisions limitations or restrictions conferred by or contained in the before mentioned Charters and any Act directly or indirectly relating to or affecting the Institution and all such rights privileges powers provisions limitations or restrictions as would or might in any way interfere with the objects of the intended Act and to confer other rights and privileges.

Printed copies of the intended Act will on or before the 17th day of December next be deposited in the Private Bill Office of the House of Commons.

Dated this 18th day of November 1919.

HARGROVE & CO 16 Victoria Street Westminster Solicitors
SHERWOOD & CO 23 Abingdon Street Westminster Parliamentary Agents B 934

IN THE MATTER OF J. W. BROOKE & CO., LTD.,
and
IN THE MATTER OF THE COMPANIES' (CONSOLIDATION) ACT, 1908.

Notice is Hereby Given

that a Petition was on the 22nd day of October, 1919, presented to His Majesty's High Court of Justice by the above-named Company to confirm an alteration of the said Company's objects proposed to be effected by a Special Resolution of the Company unanimously passed at an Extraordinary General Meeting of the said Company held on the 30th day of July, 1919, and subsequently unanimously confirmed at an Extraordinary General Meeting of the said Company held on the 15th day of August, 1919, and which resolution runs as follows:—

RESOLUTION.

"That the provisions of Clause 3 of the Memorandum of Association of the Company with respect to the objects of the Company be altered by inserting immediately after Sub-Clause (d) of that clause the Sub-Clauses following that is to say:—
"(d.1.)—To carry on business as builders and repairers of ships, trawlers, tugs, lighters, barges, motor boats and other vessels of every description and of their engines, machinery, tackle and equipment, and to purchase, hire, charter, or otherwise acquire, sell, let out on hire or charter or otherwise deal with or dispose of any such ships or vessels as aforesaid or any share or shares therein.
"(d.2.)—To carry on business as ship owners and shippers, tug and barge owners, lightermen, stevedores, carriers by land and water, forwarding agents, wharfingers, shipping agents, ship brokers, salvers, dockowners and warehousemen.
"(d.3.)—To purchase, take on lease or otherwise acquire, build, construct and maintain any docks, wharves, slips, piers, plant, machinery and other works and conveniences for the building or repair of ships and other vessels.
"(d. 4.)—To carry on business as owners of trawlers, smacks and other fishing boats, deep sea fishers, fishers, fish salesmen, ice manufacturers and cold storage proprietors."

And Notice is further given that the said Petition is directed to be heard before the Hon'ble. Mr. Justice Astbury on Friday the 19th day of December, 1919, and any person interested in the said Company, whether as Creditor or otherwise, desirous to oppose the making of an Order for the confirmation of the said alterations under the above Act should appear at the time of hearing by himself or his Counsel for the purpose, and a copy of the said Petition will be furnished to any such person requiring the same by the Company's Solicitors, Messrs. Blyth & Hornor, of 11, Upper King Street, in the City and County of Norwich, or by their London Agents, Messrs. Tarry, Sherlock & King, of 17 Serjeants' Inn, Fleet Street, in the City of London, on payment of the regulated charge for the same.

Dated the 24th day of November, 1919.

TARRY, SHERLOCK & KING,
17, Serjeants' Inn, Fleet Street,
London, E.C. 4.
Agents for
BLYTH & HORNOR,
11, Upper King Street,
Norwich,
Solicitors for the Company. B 933

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and all Engineering Examinations.—Mr. G. P. Knowles, B.Sc., Assoc. M. Inst. C.E., F.S.I., M.R.San.I., prepares candidates personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 8072

A.M.I.C.E. and A.M.I.M.E.

Tuition. Also Postal Courses in Mechanical Engineering, Aircraft Design and Mathematics.—Pennington's, 354, Oxford Road, Manchester.

TENDERS.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, ETC. are prepared to receive—

Tenders before 11 a.m.,

on Friday, the 5th December, 1919, addressed to the Secretary, H.M. Office of Works, etc., Storey's Gate, Westminster, London, S.W. 1., for the supply of Steam Tubes and Fittings (during a period of from six or twelve months from date of acceptance of Tender).

Forms of Tender, etc., may be obtained on application to the Controller of Supplies, H.M. Office of Works, etc., King Charles Street, Westminster, London, S.W. 1. B 909

TO MARINE ENGINEERS AND OTHERS.

THE METROPOLITAN ASYLUMS BOARD invite

Separate Tenders for Opening

out and closing up the engines, boiler and auxiliary machinery of the River Ambulance Steamer "White Cross," now lying at South Wharf, Rotherhithe, S.E., in accordance with specification prepared by Mr. T. Cooper, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The specification and form of Tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after 10 a.m. on 6th December, 1919, and the specification and form of Tender can then be obtained. Tenders, addressed as noted on the form, must be delivered at the Office of the Board not later than 10 a.m. on Wednesday, 17th December, 1919.

By Order,
DUNCOMBE MANN,
24th November, 1919. Clerk to the Board. B 921

INDIA OFFICE, WHITEHALL, S.W. 1,
25th November, 1919.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL is prepared to receive

Tenders from such

Persons as may be willing to SUPPLY ROAD BRIDGES (100, 80, and 60 feet spans.

The Conditions of Contract may be obtained on application to the Director-General of Stores, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that Office by two o'clock p.m. on Tuesday, 9th December, 1919, after which time no Tender will be received.

G. H. COLLIER, Director-General of Stores. B 930

CITY OF BELFAST.

ELECTRICITY DEPARTMENT.

The Corporation Invite

Tenders for the Manufacture,

DELIVERY and ERECTION at the NEW HARBOUR POWER STATION, BELFAST, of STEAM, WATER, and OTHER PIPEWORK, under SECTION "J."

The Specifications and other particulars may be obtained on application either to Messrs. Preece, Cardew, Snell & Rider, 8, Queen Anne's Gate, Westminster, S.W. 1, or to Mr. T. W. Bloxam, M.I.E.E., City Electrical Engineer, Belfast.

Tenders, upon the presented forms, must be lodged in the Town Clerk's Office, City Hall, Belfast, not later than Monday, 22nd December, 1919.

The lowest or any tender will not necessarily be accepted.

An official receipt must be obtained for every Tender delivered by hand. Tenders sent by post must be registered.

R. MEYER, Town Clerk. B 951

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

	Fee for Specification.
Locks, etc.	2/6
Stationery, etc.	£1
Brass Sheets, Copper Tubes, etc.	10/-
Pig Iron	£1

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Locks, etc.," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 9th December, 1919.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE, Secretary.

Company's Offices,
48, Copthall Avenue, E.C.
London, 26th November, 1919. B 980

THURROCK, GRAYS AND TILBURY JOINT SEWERAGE BOARD.

MAIN DRAINAGE CONTRACT No. 3.

TO OIL ENGINE MAKERS.

The Thurrock Grays and Tilbury Joint Sewerage Board invite

Tenders for the Construction,

delivery and erection of two sets of CRUDE OIL ENGINES, three sets of "Stereophagus" PUMPS, OVERHEAD CRANE and other Machinery in accordance with drawings and specification, copies of which may be obtained at the offices of the Engineers, Messrs. JOHN TAYLOR & SONS, 36, Victoria Street, Westminster, S.W. 1. These documents will only be issued to *bona fide* makers of Oil Engines.

Sealed Tenders endorsed Grays Drainage Contract No. 3, addressed to the Engineers, are to be delivered at their office on or before Ten a.m. on Monday, 15th December, 1919.

The Board does not bind itself to accept the lowest or any Tender.

By Order,
CHAS. ASPLIN,
Clerk to the Board.
High Street,
Grays, Essex. B 995

GLAMORGAN AND CARMARTHENSHIRE COUNTY COUNCILS.

PROPOSED NEW ROAD BRIDGE AT LOUGHOR

TO BUILDERS AND CONTRACTORS.

The Joint Committee of the above County Councils Invite

Tenders for the Provision,

ERECTION, and COMPLETION of a REINFORCED CONCRETE BRIDGE (Hennebique System), to carry the Swansea and Llanelly Main Road over the River Loughor at Loughor, in substitution for the present Bridge.

Copies of the Drawings and Specification can be seen and Bill of Quantities obtained, at the Offices of the Glamorgan County Surveyor, County Hall, Cathays Park, Cardiff, and at Messrs. L. G. Mouchel and Partners' office, 36-38, Victoria Street, Westminster, London, S.W. 1, on and after Saturday, 22nd instant.

Contractors will be required to pay their workmen the recognised rates of wages, and to observe the recognised hours of labour, and must produce evidence of being insured against liability for accidents to workmen.

Sealed Tenders (containing the names and addresses of two substantial sureties or a satisfactory Guarantee Society in lieu thereof), marked on the outside "Tender for Loughor Bridge," addressed to the "Chairman of the Joint Committee," are to be delivered at my office not later than 8th December, 1919.

The Joint Committee does not bind itself to accept the lowest or any of the Tenders that may be received.

By direction of the Joint Committee.

T. MANSEL FRANKLEN,
Clerk of the Glamorgan County Council.
Glamorgan County Hall,
Cardiff.
18th November, 1919. B 786

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD. (Plant and Machinery Section).

FOR SALE BY PUBLIC TENDER

VALUABLE MACHINE TOOLS, ETC., Lying at Clyno Engineering Co., Limited, Pelham Street, Wolverhampton.

Tenders are Invited for the following:—

Three Lincoln Milling Machines.
One No. 5 Fellows Gear Shaper.
Two Taft Pierce Universal Grinders, 10in. by 30in.
Four Straight bed S.S. and S.C. Lathes, 9 in. to 13 in. centres.
Two No. 9 Herbert Combination Turret Lathes.
Five 1 in. Herbert Capstan.
One Van Norman Universal Miller.
One Burton Griffiths Plain Miller by Geoley and Edlund.
Two 8 in. by 5 ft. straight bed S.S. and S.C. Lathes.
Two Milwaukie Vertical Millers, size 1½ B.
Three Landis Plain Grinders, 12 in. by 36 in.
One Internal Cylinder Grinder by Aikins, Peterborough.
One Archdale Thread Miller, 9 in. centre.
One No. 1 Slot Driller by Richards & Co.
Four Warner & Swasey No. 4 Universal Turret Screw Machines, capacity 1¼ in. Bar.
One 3 ft. 9 in. Elevating Radial Drill by Asquith.
One 9½ in. centre by 5 ft. Relieving Lathe by Smith & Coventry.
One Buckton 60 ton Vertical Single Lever Testing Machine.
Two No. 13½ Garvin Plain Milling Machines.
Three "Porter Cable" Lathes, 7 in. centres by 2 ft. 8 in. bed.
Two 3 ft. 9 in. Elevating Asquith Radial Drills.

Permits to view and all further information, can be obtained from the CONTROLLER, D.B.I.e., Charing Cross Embankment Buildings, London, W.C. 2.

Tenders to be lodged by 10 a.m., December 5th.

NOTE:—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all Bookstalls; or by quarterly subscription of 2s. post free, payable in advance, to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. B 576

APPOINTMENTS OPEN.

A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4350, Offices of Engineering.

University of Bristol.—

LECTURER IN ENGINEERING, £300—£10—£350. For particulars and form of application send at once stamped, addressed foolscap envelope to the REGISTRAR of the Merchant Venturers' Technical College. B 728

BLACKBURN MUNICIPAL TECHNICAL SCHOOL.

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JAMES BIRD, Clerk of the London County Council. B 934

12-IN. GUN MOUNTINGS ON H.M.S. "AGINCOURT."

In the different navies of the world different methods are adopted for the working of big-gun mountings. One method is that favoured by the United States naval authorities, which relies mainly upon the human element and employs only the minimum number of mechanical devices. Another, which is to a large extent that favoured in the British Navy, is to employ mechanical devices wherever possible and economise the human element. The first method, while providing less mechanical parts to go wrong, entails the use of very large gun crews, and it is a question whether there is not a greater liability to accident owing to the failure of the human element in the stress of an action, for whatever may be the defects of the mechanical devices used in the second method they certainly possess no nerves. The employment of man-power in preference to mechanical devices means also a slower rate of fire, and when one considers that the effect of a direct hit by a salvo of heavy shells is the almost certain destruction of the most powerful battleship, it would seem that rapidity of fire is an all-important aim, as the getting off of a salvo a few seconds sooner may make all the difference between the winning and the losing of a decisive action.

In the design of the mountings, which we illustrate on Plate XLIII, and on pages 704, 705, and 720, as designed and manufactured by Sir W. G. Armstrong, Whitworth and Co., Limited, Elswick, for the ship now named H.M.S. Agincourt, the second method mentioned above has been favoured, and many improvements have been introduced, special attention having been devoted to making the mechanical devices employed as simple and reliable as possible, with the result that a mounting has been produced in which increased rapidity of working has been combined with economy of men and simplicity of operation. With previous 12-in. or 13·5-in. mountings it requires a very well-drilled crew to load a gun in 30 seconds, and this speed of working can hardly ever be maintained. With the present mounting, however, there is no difficulty in loading the gun in 20 seconds; indeed, during a trial of endurance the loading operations were gone through 200 times with a resultant average of 19 seconds. The main feature of the mounting is that one lever works all the machinery in the gun-house and thus replaces four levers, and this is illustrated in the plan, Fig. 7, on page 705, and in the four perspective views (Figs. 8 to 11), on page 720. This method is also followed in the working chamber, where one lever replaces two.

The mounting is constructed to take two guns, and may be divided into the following main portions: (1) The turntable shown on the drawings reproduced in Figs. 1 to 3; (2) the armour; (3) the working chamber; (4) the trunk.

The turntable may be described as a circular platform which carries the mountings for the two guns, together with the armoured shield, and from which depends a trunk, the latter (see Figs. 1 and 2) extending downwards to the magazine and shell-room. The whole is mounted so as to be capable of rotation, to which end the underside of the turntable has fastened to it a circular roller path of steel, accurately machined to suit a ring of conical steel rollers. These rollers run upon what is called the lower roller path (also of steel), this lower roller path being carried by a suitable circular-shaped support, formed in the ship's structure.

The rollers are flanged and are kept apart from one another, and in a true radial position by means of a "live roller ring." Strong clips are provided which take under the edge of the structure supporting the lower roller path. These serve to prevent the mounting from rising when the guns are fired. The turntable is a braced circular structure in plate and angle work, and has a main centre and two side girders suitably braced together. These three girders form the supports for the slides, on which the guns recoil in their carriages, and for this purpose are fitted with trunnions, on which the slides are hung so as to be capable of movement in a vertical plane. Elevation is effected by an hydraulic cylinder below each slide. The horizontal movement of the turntable is effected by means of a circular rack, which is attached to the fixed structure, and into which is geared a pinion seen in Fig. 2. The shaft of this pinion is carried in bearings attached to the structure of the working chamber, the pinion itself being driven by a hydraulic swash plate training motor through a worm and worm wheel, as shown.

The working chamber is a light circular compartment high enough for men to walk about in, and its main function is to afford a space where the shell and cordite may conveniently be transferred from the central to the gun-loading hoist. The curved guides for the cage of the gun-loading hoists are built on to either side of the centre girders of the turntable, and extend downwards to the floor of the working chamber. The guides for the central hoist cages are straight and are built into the trunk.

The ammunition trunk (see Figs. 1 and 2) is attached to the working chamber and revolves concentrically to the roller path. Its main purpose is to carry the cage guide rails for the transport of the ammunition from the shell-room and magazine to the working chamber. At the foot of the trunk a bearing is provided for a centre pivot, which serves to guide the mounting at the bottom end, the rollers and roller path guiding the top portion.

Through this centre pivot, which is hollow, are introduced the electric cables and the air for charging the air reservoirs for supplying the air blast to the guns. Suitable walking pipes provide the means of getting the pressure from the fixed ship's structure to the moving trunk. The revolving trunk passes through a circular fixed trunk, extending through the decks. This fixed trunk strengthens the ship's structure and is made watertight.

The armour is in four parts—a front plate, 12 in. thick, two side plates, 8 in. thick, and a rear plate, 8 in. thick—all of K.C. armour. In addition to this the roof, consisting of four pieces of K.N.C. armour, is 3 in. thick at the sides and 2 in. thick in the middle. It is supported by being let into the main armour, but, in addition, there is a girder extending from the front to the rear of the shield, and eight supporting pillars, of steel, 6 in. in diameter, with forged feet and caps, arranged to strengthen the joints of the roof plates, the two middle rows of three pillars each being carried on the centre girder, and the two side pillars being carried on the two side girders of the turntable. Three sighting hoods (see Figs. 1 and 2) are provided, and one access hole, the latter affording access to the turret.

We will now briefly describe the method of working the guns. Dealing with the supply of ammunition we will suppose one of the central hoist cages to be at the bottom of the trunk. These cages are provided with means for securing the proper relative positions of the projectile and charge. At the bottom of the hoist the projectile receptacle has to be some 6 ft. or 8 ft. below the receptacle for the charges, in order that the former may be conveniently loaded from the shell-room and the latter from the magazine handing room, but when the central cage is "up" the receptacles must be close together. The lower section, which takes the shell, is connected to the upper section which takes the cordite by means of a wire rope, one end of which is fixed, to the lower section, the rope passing alternately over sheaves on the two sections and finally to a fixed end at the bottom of the truck. When the upper section is raised by the hoist cylinder the rope over the sheaves acts as a purchase, and draws the two sections together as they ascend the hoist. When the sections arrive in the working chamber they have been drawn into the required position to discharge the projectile and charge into the waiting trays in the working chamber. The cage is loaded with four quarter charges from the magazine and a shell from the shell-room by means of the combined tray and door in the shell-room and magazine handing room. This fitting consists of a door with a curved tray pivoted on brackets fixed at each side of an opening in the trunk. When in position to receive a projectile this door closes the aperture. To transfer the projectile to the central cage the tray is tipped about a horizontal axis, which is so placed that the action of tipping does not appreciably raise the centre of gravity of the projectile. When the projectile is discharged into the cage the door returns to its original position under the action of a spring and closes the aperture. The whole process of transferring a projectile from the tray to the cage can be performed in less than 1 second, and is effected by a lever at the side of the door.

When the doors of the hoist are shut the cage can then, and then only, be raised by means of the central cylinder, the action of which is controlled by the central hoist working valve situated at the top of the hoist and operated by the single lever gear in the working chamber. Arrived at the working chamber the shell and cordite charges are automatically discharged into waiting trays in line with the gun-loading hoist cage, when in the "down" position. By the action of the single lever the flash doors at the end of the waiting trays are opened, and the shell and cordite charges are transferred to the gun-loading hoist cage by the hydraulic rammers shown in Fig. 4. The rammers are next returned to the "in" position, the flash doors closed and a signal lever, on the single lever standard, moved to "free," leaving the gun-loading cage free to be raised to the 5 deg. loading position in the gun-house.

We now come to the loading operations controlled from the gun platform. The gears which are worked from the gun platform when loading the gun, viz., breech, 5 deg. loading position, gun-loading cage, and chain rammer, are operated by means of a single lever placed at the rear of the gun, as shown in plan on Fig. 7 and the perspective views on page 720. This lever is mounted on a universal joint at the bottom of a box-shaped structure and has a projecting pin on each of its four sides; these pins engage in grooves at the ends of levers which are pivoted in bearings carried on the sides of the box, and are connected to the control valves of the various gears. The top edge of each side of the box is turned down to form a clip, which engages with a corresponding upturned clip, formed on each of the four sides of the single lever, thus making it impossible to move the lever in any direction except along the sides of the box. At the first three corners of the box the turned-down edge on each side is cut away, so that when the single lever is brought to any of these corners, the clips on the lever which engage with the turned-down edges of the box are opposite the notches, and the lever may be moved in a direction at right angles to its previous motion to perform the succeeding operation. No cutting is made in the turned-down edge at the end of the fourth side of the box, so that the single lever marked I in Fig. 8, page 704, can only be brought to its original position by reversing it round the four sides of the box.

When the single lever I, on Fig. 8, is moved along the first side of the box, in the direction of the arrow, the pin on the single lever, which engages with the groove at the end of the lever connected to the breech valve N, carries this lever across the front of the box, and the pin on the adjacent side of the lever enters the groove at the end of the lever on the adjacent side of the box, which is connected to the slide locking valve L. On the single lever being moved along the second side of the box to operate the valve D, the pin on the front side of the lever leaves the groove at the end of the lever on the front side of the box, which is secured in position by means of a spring catch. The other levers are operated in the same manner.

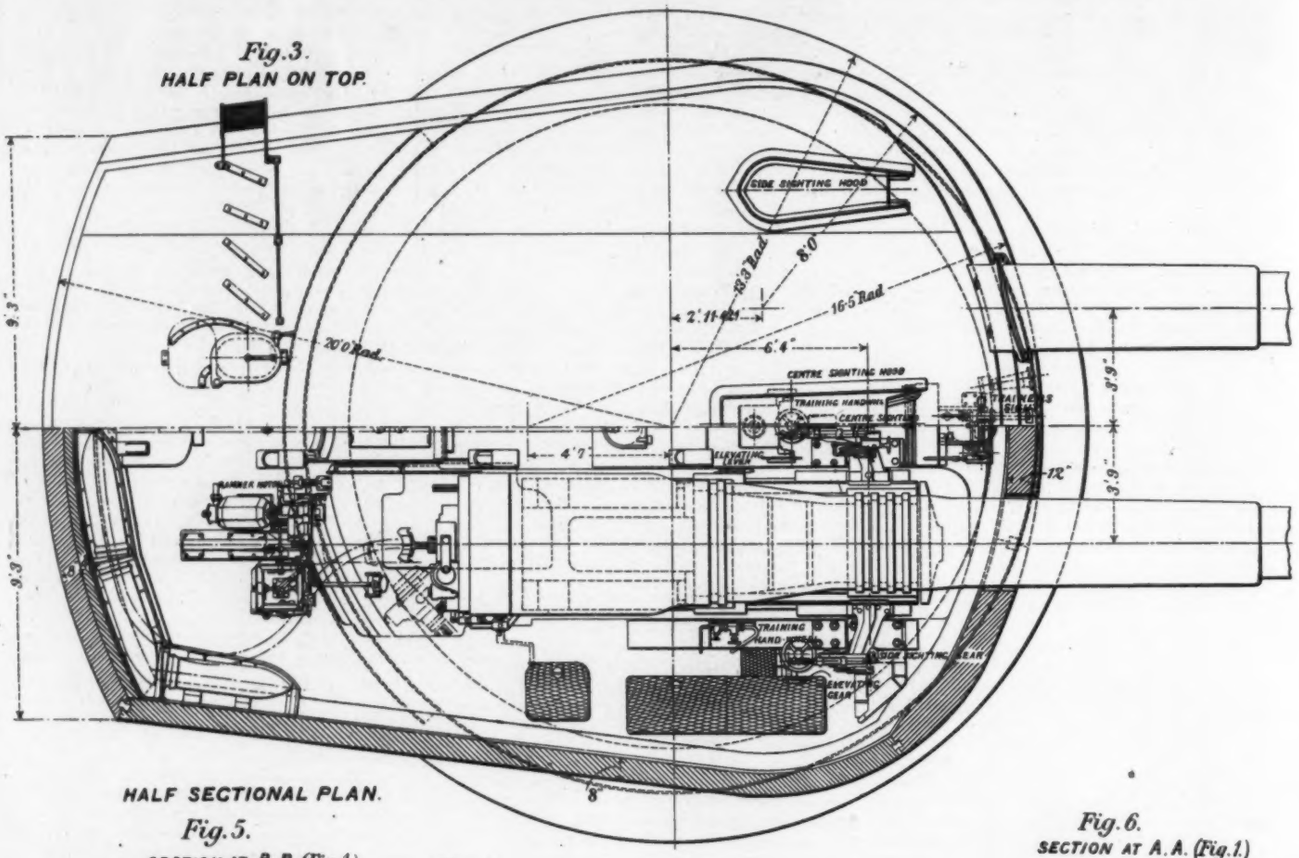
The loading operations are performed in the following order: (1) Open breech (Fig. 9, page 720); (2) lock gun at loading angle (Fig. 10); (3) raise cage (Fig. 11); (4) ram shell and charge (Fig. 12). These operations may be carried out independently as the operator working the single lever has complete control of each operation, or should it be desired to allow the various operations to take place at the same time instead of separately, the lever I can be moved rapidly along the first two sides of the box, and also along the third side—provided the locking bolt P, which is operated from the working chamber when the gun loading cage is charged, has been withdrawn—and as far as the bolt J on the fourth side, this bolt only being withdrawn when the cage is in line with the gun at the loading angle.

The movement of the lever along the first side

TWIN 12-IN. GUN MOUNTINGS FOR H.M.S. "AGINCOURT."

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, ELSWICK, NEWCASTLE-ON-TYNE.

Fig. 3.
HALF PLAN ON TOP.



HALF SECTIONAL PLAN.

Fig. 5.
SECTION AT B.B. (Fig. 1.)

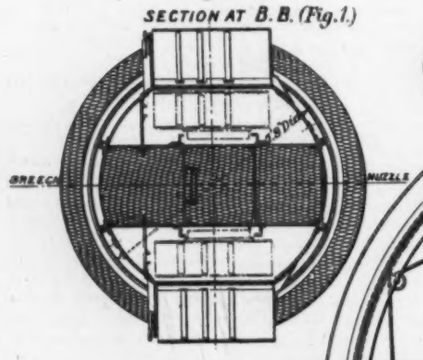


Fig. 4.
PLAN OF WORKING CHAMBER

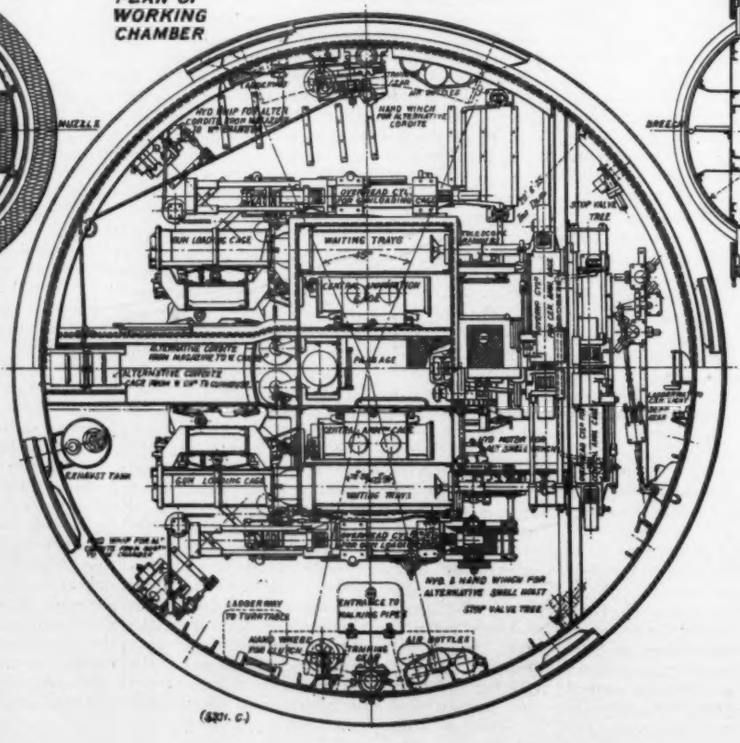
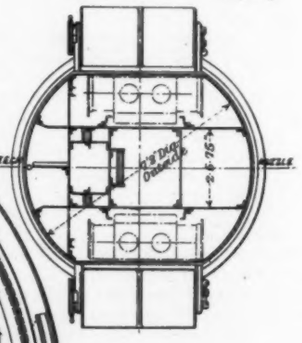


Fig. 6.
SECTION AT A.A. (Fig. 1.)



of the box operates the breech valve N, and supplies pressure to the breech engine F to operate the breech, the motions of the breech being slowed down as required by means of the intercepting valve Q operated from the breech engine.

ammunition is transferred to the gun-loading cage by the telescopic rammers as described above.

When the cage is raised the lower tray containing the projectile is first in line with the gun, and as the rammer moves forward the shell is transferred to the

the sight on to the target in the vertical plane and fire.

The elevating is controlled by means of a lever standing vertically when the elevating control valve is centred. The gun layer pushes the lever from

Fig. 7.

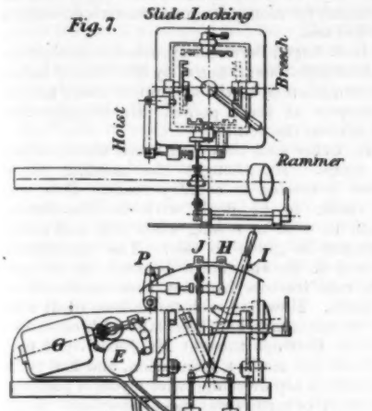
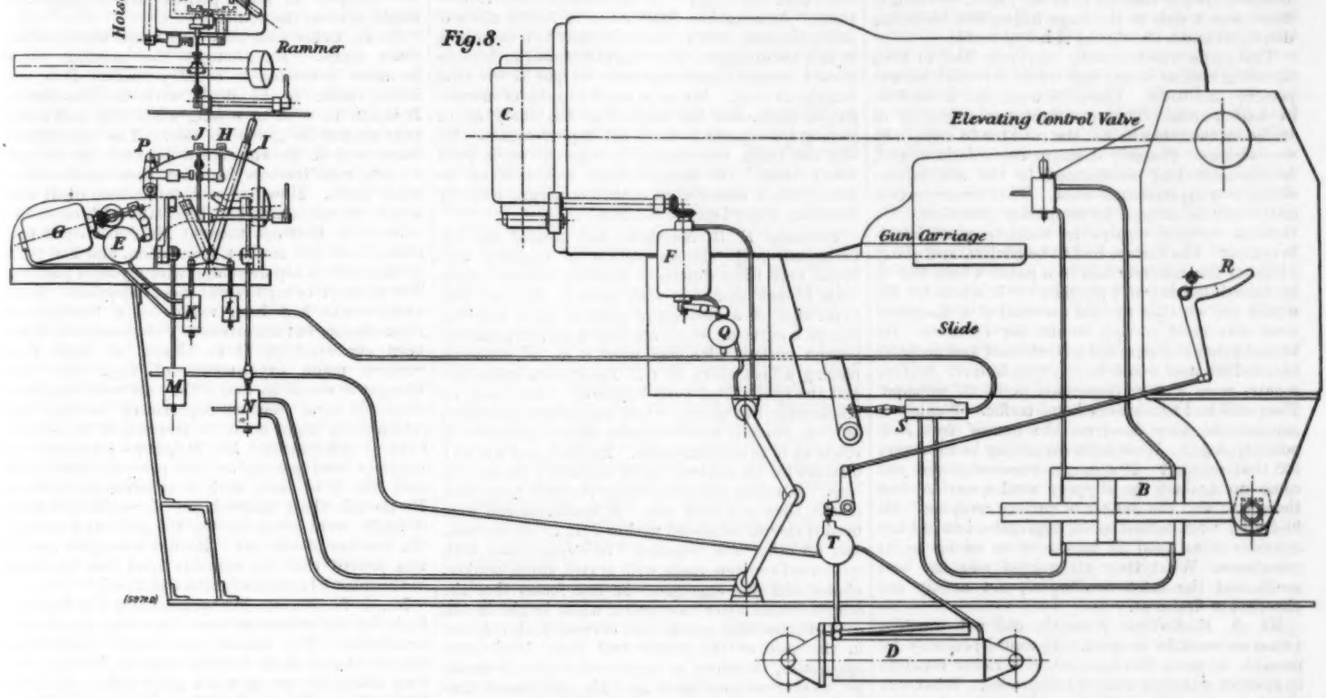


Fig. 8.



The movement of the lever along the second side of the box operates the slide locking valve L, and puts into operation the valve S which controls the motion of the gun towards the loading angle position.

The motion of the lever along the third side of the box operates the gun-loading hoist valve M, and supplies pressure to the hoist cylinder D through the intercepting valve T, which, in conjunction with the lever R, operated from the gun slide, controls the motion of the cage as it approaches the gun.

The motion of the lever along the fourth side of the box operates the rammer valve K, and supplies pressure to the rammer engine G through the intercepting valve E, which slows down the motions of the rammer as required.

When ramming the shell, both the bolts J and H are withdrawn from the path of the single lever, and the lever is given its full stroke to place the shell in position in the gun. On the rammer being withdrawn and the cordite brought into line with the rammer, the bolt H remains across the path of the lever, thus limiting its stroke and causing the rammer to perform only sufficient of its stroke to place the cordite within the chamber of the gun. The second half-charge on being dropped into line by the return stroke of the rammer is placed just within the chamber of the gun and pushes forward the first half-charge. Once the lever I being moved round to its original position the operation takes place in the reverse order, and the intercepting valves slow down the motions of the gears as required.

The gun-loading cage is composed of two principle parts, the containing frame to which the lifting rope is attached, and a sliding frame working within this. The sliding frame is fitted with three trays arranged horizontally one above the other. When the cage is down in the working chamber these three trays are respectively in line with the two waiting trays holding the half charges, and the waiting tray holding the projectile from which the gun and rammed home. On the return stroke the rammer head releases two catches, one at each end of the cage, which action allows the three trays to fall one stage, and brings the middle tray into line with the gun so that the first half charge can be rammed. Again the rammer is returned, and again it releases the two catches, with the result that the trays drop another stage and the second half charge comes into line with the gun and can be rammed in. When the last half charge has been placed in the gun the single lever is moved along the sides of the box in the reverse direction, and the breech is closed and the gun released from the loading angle, but only when the cage has been lowered clear of the gun. As the cage descends the trays are returned to their position within the containing frame ready for being recharged.

The turret is trained by one man placed centrally at the front of the gun-house. He is given a balanced telescope which is independent of any motion of the guns. It can be adjusted for deflection in a horizontal plane, and, being carefully hung on pivots, the mere pressure of the face against the eyepiece, with the help of a pad resting on the head and attached to an arm extending from the telescope, is enough to control the telescope. The trainer, therefore, has both hands free to manipulate the training wheel, and is thus given every facility to keep his turret and its guns trained on the target.

The right gun is elevated from the right hand position and the left gun from the left-hand position, and from both of these positions the turret may be trained if desired by means of the training hand-wheels provided. There is a second centre position from which either or both guns can be trained or elevated, but this is only a "spare" position. It may be taken as a general rule that since training is controlled from the forward central position, and takes place during the time spent in loading the guns, the guns will always be trained to the right position before they are ready to be fired, so that the man at the elevating station has only to bring him when he depresses the gun or draws it towards him when he elevates. A lever offers an advantage in that it is easy to apply a very simple firing trigger to the handle end, so that the gunlayer need not shift his hand to fire when he has adjusted the elevation.

ROADS AND TRANSPORT CONGRESS AND EXHIBITION.

The Roads and Transport Congress held by the County Councils Association opened at the Royal Agricultural Hall, Islington, on Friday, 1e 21st inst., at 11 a.m., with the discussion of two papers, reprinted elsewhere in this issue. The first paper was by Mr. W. Matthew Jones, M.Inst.C.E., and was entitled "Reinforced Concrete Roads, their Construction, Maintenance and Life." The second, entitled "Cement-Concrete Pavements in New Zealand and the United States and Canada," was by Mr. W. E. Bush, M.Inst.C.E., of Auckland, N.Z.

The chairman, Mr. A. C. Pain, first called upon the two authors to give a brief summary of their papers, and the discussion was then opened by Mr. H. T. Chapman, who said that they were grateful for the experimental work which had been done in this direction by Mr. Matthew Jones and wished him success in his further trials. Mr. Jones had referred to the speaker's report of 1910 on some of his work. He supposed that practically all engineers, if they had experimental work to do over again would, on more mature experience, be able to carry it out on better lines. He admitted that was so with his tests. They were all agreed, probably, that both concrete and reinforced concrete were good for general work, but it was not yet decided that these systems gave a good surface for roads. In his report he had perhaps, owing to his extreme anxiety to be fair in connection with his tests at Gravesend, conveyed an incorrect impression that concrete gave rather disappointing results. Concrete was not resilient or elastic. He thought these qualities were desirable for all types of traffic.

In the United States roads were treated with a surfacing coat of bituminous material. This might provide the necessary resiliency and prevent surface abrasion. Expansion joints were necessary, but they should not be overdone. If there were too many they became a source of weakness. Cracks often appeared at the end of the day's work from poor bonding. He considered there was danger in two course work owing to the risk of the first course having taken its initial set and there was poor cohesion between the courses as a result. In the Hassam system referred to in the paper, he thought there was a risk of the large aggregates becoming displaced under the shocks of heavy traffic.

The roads which county surveyors had to keep up could not be closed and traffic diverted, as was possible in a town. Therefore work had to be done in half widths. This resultant concentration of traffic on the other half of the road for 28 days or so was serious. Possibly it might cause failure, and, he thought, had contributed to the non-success of his own experimental work. That concentration could only be avoided by temporary diversion. He thought surface repairs to concrete were heart-breaking. The surface had to be hacked, and about 1½ in. of fine concrete laid in a patch which had to be fenced, lighted and watched till it was set. He would ask whether the old material of a macadam road was good enough to use for concrete. He thought that if it were not well cleaned and properly handled the user would be courting failure. Surface repairs were a very important point to consider. They still had to consider horse traffic. Would not concrete be very hard on the horses' feet and, possibly, legs? Would not carpetting be necessary for that reason? If a carpet were employed you came up against the slippery road question, and there was also the danger of surface creeping. He had used river ballast as an aggregate, but did not consider it as good as broken stone owing to its roundness. What they all wanted was the best roads and the most economical, not merely the cheapest in first cost.

Mr. A. E. Collins, Norwich, did not consider two-coat work to be good. It would probably be possible to use a thinner coat of a richer concrete in place of a thicker coat of two grades. What was the poorest mixture which would give sufficiently good adherence and what was the least depth possible for different classes of roads? If a road acted as a raft he thought a top reinforcement as important as the lower. If on stable ground, he thought the reinforcement should be at the top. the concrete below acting more or less as a pad, The reinforcing was required on the top to resist temperature changes. With regard to the question of foothold, had anyone tried mixtures of various materials, such as broken brick, with the concrete so as to obtain uneven wear to keep the surface rough. He would always prefer a plastic surfacing over concrete. Even ¼ in. would make a lot of difference in the load per inch. He thought America could teach us a lot in regard to mechanical methods applied to road-making. If our costs were to be kept down such methods would have to be adopted.

Mr. L. Roseveare, South Shields, stated that his borough had 20 miles of concrete, not reinforced concrete, roads on clay soil. These had taken continuous traffic, including steam lorries. Some had been down from fifteen to twenty years. His experience went to show that concrete would not stand up to steel tyres. Had a suitable jointing material been found for expansion joints? This greatly affected the life of such roads.

Mr. J. A. Brodie, Liverpool, said the subject was a large one and deserved very careful consideration. They had not had much experience of the wear of concrete under steel tyres. They of the municipalities were indebted to the County Council Association for bringing up these points, when everybody had to consider very carefully the whole question of increased costs and the less value they were getting for money paid out for labour. The whole thing was a question of value. His costs for sett paving had gone up 200 per cent. over pre-war rates. For soft wood paving the increase was the same. For macadam the increase was 100 per cent., and for concrete 100 per cent. The effect actually was that concrete came out at present about the cheapest material to put down. He could put down a concrete road about as cheaply now as one of macadam. That sounded extraordinary, but explained his conditions at present. Liverpool had used concrete foundations for road paving since 1872. In the last ten years he had put down concrete, but coated with pitch mixture. In some cases he had used 3-in. coating; in others, 1½ in., and down to ⅝ in., according to the type of traffic. He had also put a ¾-in. coating on paved granite surface, and found it was wearing well. He did not think the "grip" of the coating need trouble them. America had 8,000 miles to 10,000 miles of concrete roads, and we here were only now beginning to talk about them. He thought the local authorities should compel their engineers to put down trial lengths of road. We were much too shy of investigation work, and the authorities too chary about paying for experts to work out improvements. He did not think the repairs to concrete roads need worry them. He thought these would better be done with a material of asphaltic nature than by inserting a thin layer of concrete.

Professor E. R. Matthews had carried out experiments with various classes of concrete and found very little difference between concrete made with broken stone or with gravel. He had had experience of a two-course road of plain concrete laid on a curve on which all other material tried had proved useless. He had used 8 in. of concrete, placing a lath every 10 ft. These were taken out and the space filled with bitumen. There were no cracks after five years. There was no reinforcement, but he thought reinforcement often advisable in roads as in other structures. He had used a 6 to 1 mixture for the bottom course and 4 to 1 for the top coat. A richer concrete would develop more hair cracks than a poorer one. If reinforcement were used it should be placed within 2 in. of the bottom, and no other was required. In experiments with reinforced concrete made with gravel, stone, clinker, cinder and slag aggregates he had found that the reinforcement after two years, while bright in the case of stone and gravel, was covered with red rust in the case of the cinder and slag. With such aggregates, therefore, in a reinforced road, it would get weaker as time went on. He understood that in the United States no traffic was allowed to go over a new concrete road for three months. That made them impossible here.

Councillor Rowlands, Tilbury, said a length of concrete road laid down and taking the traffic from the Tilbury Docks, cost them practically nothing as regards maintenance. The surface had been heavily tarred, but that was wearing off. So satisfied had they been with this result that they had schemes to spend 37,000*l.* on reinforced concrete roads. They thought two-coat work best. They used a local gravel for the bottom and granite chippings for the top. Both coats were laid together with excellent results.

Mr. Max Clark, Holborn, asked what the authors meant by concrete roads. All central London had concrete under the roads varying from 8 in. to 18 in. in thickness, mostly not reinforced. Had Mr. Jones considered the question of attrition of concrete roads without surface covering? As regards the position of the reinforcement he agreed with Professor Matthews. It should not be at the top. The reinforcement took the tension and the concrete the compression; therefore the reinforcement should be below the neutral axis. He was more or less responsible for the granite paving at what he called Tottenham Circus. This was laid over concrete and cost 3½*d.* per yard per annum for repairs which simply consisted of filling the cracks with bitumen. Previous materials had cost 4*s.* per yard per annum for repairs. With a good bottom, 6 in. of concrete might do; other places would want 18 in. The difficulty in London with regard to reinforced concrete roads was the continual taking up and relaying of the surface in connection with pipes and other services. If a properly-reinforced road were put in and then cut lengthwise by a trench the whole thing was at once spoilt. In Southampton Row a new concrete road paved with wood had been laid for 2*l.* per yard. Traffic was diverted from May 27 till October 7, but this long time was due mainly to lack of labour. Could the authors account for the circular depressions which occurred in concrete, of about 6 ft. in diameter. These were found under the surface, though the soil was equally good everywhere. The Government was spending money on research. Why should not the County Councils Association apply to the Government for money for road research on definite scientific lines.

Mr. R. J. Angel, Bermondsey, asked, in connection with the depressions spoken of by Mr. Clark, if he had any information as to the amount of water used in the concrete at these points. He thought that might bear on the point.

Sir R. Usher said they had heard mostly about town roads. He thought the meeting would be more interested in country roads. How was horse traffic to be dealt with in the future. It would be with us a long while yet, and attention should be given to this. The agricultural horse had to be considered because up till now at any rate tractors had not been successful in many parts. How had such traffic been dealt with where country roads had been laid with concrete?

Mr. C. F. Gettings thought Mr. Jones' road misnamed. It was really a foundation, and had to be protected by a top dressing, twice a year if possible. The question of repairs was most important. Road experiments had been made by a Government Department, but unfortunately the results had not been conveyed to them. Many of them had, further, made experiments of their own. He thought it would be well if they all were to submit these to some central department so that the information might be at the disposal of the County Council Association. Mr. Matthews gave costs of concrete road paving as 13*s.* per superficial yard and 25*s.* if of setts with a concrete foundation. He thought these figures high. It would be helpful if traffic were given by the ton-yard and not by the number of vehicles. He did not agree that it was proved that the concrete road was the road of the future, because of surface troubles.

Mr. J. W. Horton, Derbyshire, said 17*s.* was too high for tar macadam even including a concrete foundation. For towns they could understand concrete being used, but for country districts the time taken for setting was a great objection, apart from others. Traffic should not be turned on to it for 30 days. If they laid at the rate suggested (100 yards per diem) there would be about 2 miles of road out of service at a time. It was quite impossible to find alternative routes on this scale in the country. Why they had been possible in the United States of America was, he thought, because the previous roads were unmetalled and were so rough that if the traffic were turned on to the road-side while the new road was being laid it made conditions little, if any, worse for it. That was not possible here. Then, again, the slippery surface question came up. If a concrete road could not be used without a top bituminous coating it would not do for the country.

Mr. Wilkinson, Willesden, said when at Deptford he had put down a concrete road 9 in. thick, *i.e.*, 6½ in. of under coat and 2½ in. of over coat, reinforced at the bottom and top. He had put in the top reinforcement to see whether this would take up the stresses set up in the upper layers by starting mechanically-propelled vehicles. This road took most of the cattle market traffic. It had been down five months, and was not tarred. At one point where the top coat had been floated the fine surface was giving slightly, but nowhere else. It had been put down for experiment. It had cost 17*s.* per superficial yard for concrete reinforcement alone. It had not cracked, except where jointing was done. He thought it would prove all right.

Mr. Jones, in reply to the discussion, said with regard to elasticity he believed in tar spraying of the surface. That only cost 2½*d.* to 2¾*d.* per yard in Chester, and that was not dear for the protection it gave. He had not had to do surface repairs as yet, and he hoped to take all repairs in hand so early that hacking out would not be necessary. After a frost he had gone down to see his concrete road in Chester, and had found all the horse traffic coming into the town on the wrong side of the road so as to get off the wood-block paving on to the concrete. He used ¼-in. granite chippings with his spraying.

Two-coat work was not desirable. It was more expensive than one. More experience was needed with regard to the qualities of the various possible materials. Mechanical methods were all right where large quantities were involved, but surveyors often had to deal with short lengths. He thought joints might be put in at 45 deg. instead of straight across the road, with good results. The difficulties of opening up concrete roads were considerable, but if notice were given and some encouragement given people would have their pipes, &c., examined before the road was laid.

Mr. Bush, in reply to points raised on his paper, said they must have an unyielding surface if the best results were to be secured for traction effort. Concrete had provided this in the United States of America. He had abandoned the two-coat system, but had sometimes put down broken metal first. Concrete roads must be closed for 28 days at least. He thought that difficulty might be met on main roads. He had managed to do half the road at a time on all roads of reasonable width. He had not had to do any surface repairs, but did not anticipate difficulty therewith. He had only reinforced over trenches where he thought he might have trouble. With mechanical mixers, in the United States of America 300 lineal ft. or 600 sq. yards per day were laid. This was partly due to excellent organisation. In Auckland, mechanical methods were used. Of course, everybody would prefer rubber tyres. If they were used for trucks concrete floors would not suffer. He used joints of two thicknesses of tarred paper every 56 ft., painted over. In the United States they were practically abandoning joints, and where cracks appeared they simply tar-painted them. There they had some 10,000 miles of road, 90 per cent. to 95 per cent. of which were equivalent to our country roads, taking all types of traffic. Farmers thought them a great asset. He had laid 45,000 sq. yards in Auckland, at 12*s.* a yard for all charges, though material and labour before the war had cost about twice as much as in England. All but two of his roads were unsurfaced. In some cases surfacing was an advantage and quite a thin coat would suffice.

The following resolution was then put to the meeting: "That this conference is of opinion that the question of the construction and maintenance of roads is at the present time a matter of the utmost importance, and should therefore be the subject of scientific investigation subsidised by the Government." This was duly seconded and carried unanimously. After votes of thanks to the author and the chairman, the meeting adjourned till the afternoon.

Asphaltic Macadam Roads.

On reassembling at 2.30 p.m., the conference considered a paper by Mr. H. T. Wakelam, M.Inst.C.E., entitled "Asphaltic Macadam (Bituminous) Roads and their Extended Use." This we reprint on another page of this issue. Mr. C. F. de Salis was in the chair.

After introductory remarks by Mr. Wakelam the discussion was opened by Mr. A. Dryland, county surveyor, Surrey, who said that in Surrey they had used asphaltic construction, having commenced in 1910 and greatly enlarged their area since. They had now a quarter of a million yards of such road surface, equivalent to about 20 miles. The author had dealt with one particular kind of asphalte, but made mention of residual bituminous materials. He the speaker, preferred to test a variety and find out which promised best. He had about 65,000 yards of residual bitumen roads giving promise of very long life. Part of the Great Western-road taking the lorry traffic from Kempton Park during the war, as well as timber traffic, &c., had been laid with this. The repairs had been very small. In 1913 he had been so satisfied with the results of the asphalt roads that he had induced his authorities to purchase a special plant to enable him to undertake work himself. He had thought that local resources might advantageously be employed. His base coat he had made of the old macadam road crust, suitably treated. He had reconstructed the base of 13 miles of road with this old road metal mixed with pitch and oil. He had not had to bring to it any new material. It was still perfectly sound and good. For the surfacing coat he had used mostly a local sand which he had searched for and found, or clinker. His plant he put down near the sand to save cartage. In 1915 he managed to lay base and top coats together for 4*s.* 8*d.* per yard, while the author was paying 10*s.* or 8*s.* He thought this proved that, utilising local materials, the cost of such roads could often be cheapened. He had employed Trinidad asphalt, and the grading was similar to the authors'. He had had no repairs to execute in the five years, except over trenches, which always gave trouble. Recent trenches always showed themselves, but otherwise no surface repairs had been required. He anticipated a probable life of ten to twelve years, possibly more Patches could readily be let in and traffic allowed over the repairs in a few minutes. That was a great advantage.

As regards fillers, he had tried many, but did not think the actual material mattered much, so long as it was inert and finely ground. He had used road dust, and thought cement altogether unnecessary and expensive. Pitch and tar were not outside the question as the author stated. He had used no bitumen in his base coat, and did not intend to. Pitch compounds were excellent in a base coat, and were much cheaper. By the use of local material he was able to do a lot of work during the war which would not otherwise have been possible. Clinker asphalt made good roads, but was not available everywhere or in large quantities. It also had to be ground, and took more bitumen than sand. Unless clinker was an otherwise waste product its use was not advisable. He considered the asphaltic form of construction with a good base coat of either bitumen or pitch, gave the best road for mechanical transport. The wear was very small. Though the foothold was not absolutely everything that might be desired, under many conditions it was better than others, while taken the year round the complaints were really extremely few in number.

Mr. J. Carey, Isleworth, had been associated with Mr. Wakelam and the roads mentioned in the paper were on the boundary of his area. They had to carry much horse traffic with market garden produce, and the horses soon became accustomed to the asphalt surface. When he had brought the question of clinker to Mr. Wakelam's notice the local authorities had been placed in the position of putting to good use an otherwise absolutely waste product. At the same time, as they could not finance the bituminous road schemes it had been arranged for the District Council to provide the base cost, while the County Council paid for the wearing surface. There was no special selection of clinker. It was taken from the destructor to a heap where it continued to burn. Even all the tins were not taken out sometimes. The larger material was used in the base coat and the finer for the upper coat. It must be remembered in connection with corrugations that in laying a road the old road usually had to be excavated, and there was a continual consolidation of the sub-base going on. Contractors usually gave a ten years' maintenance guarantee for such roads. If steel tyres could be eliminated there would not be the need for such resiliency in the road. With rubber tyres it would be possible to put into the wearing surface a stability which could not at present be adopted.

Colonel R. E. B. Crompton said he had traversed the roads dealt with and would give all due credit to the engineers who had designed what he called the bituminous carpet type of construction. There was a great difference between the natural asphalt which was expensive, and synthetic asphalt which was a bituminous mixture of sand and other things, made by themselves. Mr. Dryland had, he thought, done more than anyone for roads by making experiments in the right direction. Carriage bulked very largely in the costs and Mr. Dryland had tried local and old material with new binders. He had extracted part of his material from the old metal. Road dust made a good filler if properly sifted. He had found that the best sub-crust was the old material itself. That he, the speaker, considered quite good, and pitch and oil mixture was quite good for sub-crust where it was protected by the upper layer. When roads were first made with pitch and tar the minimum proportions were not adhered to, and care was not taken to see that just the right quantity of pitch was used to cement the material together. When a road was properly made, corrugations were not necessary. They were avoided if stone to stone rolling were adopted without the hogging applied in the late Victorian days. All the hogging between the stones worked out, leaving them all slightly spaced apart. The heavy traffic moved them, crowding them up into the crown of the waves with greater spacing in the troughs. When proper stone-to-stone work was done below and a carpet was applied above, waves did not occur. Waves and corrugations occurred beneath the carpet, He believed bitumen would have to be used for the upper coat. It was chemically stable. Pitch exposed to air did change chemically, and deteriorated. Therefore tar and pitch might be used below, but bitumen with sand or clinker should be used for the upper coat. The double-coat system saved cartage by using the old road crust, and only the more expensive material had to be imported. Old chips from quarries made a good upper surface material. In Scotland they were being laid by machine, which laid a depth of $\frac{3}{4}$ in. of chips over a width of 7 ft. at the rate of 4 miles per hour, the road being tar-sprayed first. Owing to the great rise in price of materials and labour, road engineers would have to see that simple machinery was introduced. The Thames Embankment was the pioneer piece of double-coat road in this country, and all honour was due to the contractors who did the work there.

Mr. R. Drummond, surveyor of Renfrewshire, said that some three or four years ago he had become interested in seeing whether they could not utilise the débris from a large number of quarries. The material he referred to was of $\frac{3}{4}$ in. downwards. He wanted to produce a surface such as they found in London, and he thought all the material he could get could be utilised. In 1917 he had put down two experimental lengths, using this waste. On one road they had a traffic of 500 tons a day and on the other about 3,000 tons per diem. The latter was wide, with tram lines in the middle. In June, 1919, it was just as good as when laid on this heavy road. Previously macadam had had to be renewed every two years. The result was that in 1918 they had procured machinery, and they had now seriously started to put down this kind of surfacing. He considered it a reply to the advocates of concrete. The old material might be used. He had dumped a cartload of his mixture without consolidating it, and after two years it was impossible to pick a single particle off the pile. In 1917 the cost ran out to 3*s.* per superficial yard, 2 in. thick. This year the cost was approximately 5*s.* That was only approximate, as his quantities had not been large enough to get at fair figures. That included an estimate for the cost of the stone. In order to get stability he had found it necessary to use at least 25 per cent. of the $\frac{3}{8}$-in. size, and equal amounts of bitumen and dust filling. He thought the $\frac{3}{4}$-in. size gave stability and the fine dust the toughness. The cost of the stone was about 12*s.* per ton.

Mr. W. E. Bush, Auckland, N.Z., stated that three types of asphalt roads were used in the United States, viz.: (1) Sheet asphalt, which consisted of a coat of $1\frac{1}{2}$-in. stone, $1\frac{1}{2}$ in. thick, and on top a surface course of asphalt and fine cement or good lime. He did not think cement necessary. (2) Bitulithic, using as an aggregate absolutely every size of stone very carefully proportioned to fill all interstices, with asphalt. (3) Indurated asphalt, which he had seen in San Francisco. This was a two-coat road. The bottom consisted of six parts broken stone of $\frac{1}{2}$ in. to $1\frac{1}{2}$ in., three parts sand and one part asphalt. The top coat was $13\frac{1}{2}$ per cent. asphalt, 15 per cent. dust, and 71 per cent. sand. This was laid to thickness of $1\frac{1}{2}$ in. He thought the sheet asphalt roads in the United States of America very fine. Some had been down twenty-five years, and the maintenance costs had been very small. About 6 in. of concrete was used mostly, except in the roads of class (2), when rolled broken stone was employed below the coating material.

After remarks by Mr. A. Lyddon, of the North Riding, Yorkshire, to the effect that the question was largely one of costs, Mr. Wakelam's system

involving expenditure which would be prohibitive in many cases, Mr. Marriott, of the Limmer Asphalt Company, said that the author's system represented the mean between tar-spraying and what be called rock asphalt. He thought asphaltic macadam to the Middlesex specification was the solution for roads with moderately heavy traffic. Future traffic would justify quite large expenditure. The author attributed wave formation to vibration and friction. The speaker thought that not correct. If that was the fact waves would be accompanied by disintegration. He thought no type of pavement was so little affected by vibration as asphalt, or gave a better foothold. He thought waves due to the instability of one of the three layers. Whether they excavated or used the old material, much more attention should be paid to the sub-base. It would then be possible to evolve a second layer of asphaltic concrete with compressive qualities comparable to those of hydraulic concrete. That could be procured by raising the melting-point of the matrix, but on the present sub-course it would not be possible for such a layer to be rolled down. Over that you might have a thin veneer as a wearing surface. With asphaltic macadam the internal stability would increase as harder types were introduced and wave formation would then disappear.

Mr. J. A. Brodie, Liverpool, stated that he agreed with Mr. Wakelam in many respects. In 1899 he had had similar material put down by Mr. Marriott, who was at that time rather doubtful as to being able to give a ten-year maintenance guarantee. It was laid for 10*s.* per superficial yard. That road was good to-day, and had needed very little maintenance. In every year between 1899 and 1914 they had increased the area laid in Liverpool, and now had over 50,000 sq. yards all laid on the ten-years' maintenance system. His only trouble with contractors was that he would very much like them to put down roads at a cost which he had found possible. When the contractors were charging 10*s.*, he himself had been able to lay corresponding material for a cost of 4*s.* That material would probably cost 20*s.* to-day, and was not suitable for all classes of traffic. In the author's case the class of laying proved a cheap bargain. The traffic was large and the life good. Much cheaper materials would have to be used on most roads of this country. He had taken up old material, riddled and mixed it with pitch mixture and sand, with good results. The wearing surface had stood up to traffic for twelve years. He thought Eng'ish materials could be got to give as good results as imported foreign.

Mr. Wakelam, in reply to the discussion, said he preferred to rely on contractors bound by a maintenance clause rather than to attempt to get good results by employing untrained workmen and involving possibly considerable subsequent expenses. He also preferred to put his new material down over his old if possible, and thereby got a stronger crust than if the old were taken up and re-used in the new. Clinker from destructor had been used with certainly very good results. If limestone chippings were used with tar painting instead of granite, they would find much of the slipperiness would disappear. It was the general concensus of opinion that waves and corrugation were due to vibration and friction. The faster the speed the closer the corrugations. The modern trouble was due to the motor omnibus. If they took present costs and applied it to the road yardage of the country the total figure would be found to be extremely high for resurfacing to cope with the mechanically-propelled traffic of the future. The form he advocated might not be suitable to all roads, but he was convinced its use would be extended largely.

A vote of thanks was then passed to the author and the chairman; Mr. de Salis, in acknowledging the latter said they heard a good deal about horse traffic. He thought that as the new roads were necessary for the modern motor traffic inventors might with advantage turn their attention to the development of some new form of horseshoe to suit the new conditions. The conference then adjourned.

Highway Law.

On reassembling, at 11 a.m., on Saturday the 22nd, the chair was taken by Mr. F. Dent. The paper for consideration was entitled "The Consolidation and Amendment of Highway Law." Its author, Mr. H. H. Copnall, was called upon to give a few introductory remarks. The paper reviewed the present condition of highway law, and pointed out that much of the present law had come down to them from times when totally different social conditions existed, dating as far back in some instances to the time of Henry VIII. The paper argued in favour of a comprehensive classification of the roads, and put forward for consideration a sketch of a Bill amending and consolidating highway law.

Mr. Berryman, Somerset County Council, said the Minister of Transport had lately promised that classification should be promptly taken in hand. Everyone would welcome that. It was the first step. Though consolidation of the law was necessary he thought amendment should come first. Highway improvement were often interrupted by the action of private individuals; for instance, as regards buildings on the road side. Power should be given to lay down proper building lines. Proper road-planning schemes should be thought out to provide suitable and wider roads in the more congested areas. Powers should be given to prevent dangerous corners, high fences, &c., at corners, and so on. The private individual had, it was recognised, a right to light. Therefore, he thought the public should have the right to see. The highway should be used by all with full regard to fellow users. That was partly a matter of education, but he would like to see the police in control of all road traffic. The roads should be used with due regard to what other traffic there might be on them.

Mr. A. Evans said they had got to the stage when road traffic was essential to the nation. He was a user of roads, and suggested that rules such as those adopted at sea should be properly drawn up and enforced by statute law. At present traffic rules could only be enforced by bye-laws. Mr. J. W. Horton, Derbyshire, who followed, said he agreed with both the amendment and consolidation of highway law. Everybody knew of the importance of draining roads. He thought powers should be given to the highway authorities to take ditches and drains essential to the roads under their charge. Further, they ought to be able to control the drains running from these to the main drain or river. If these were not properly attended to, the ditch became a soak-away, and the road foundations suffered. He thought there should be no distinction of conditions with regard to mains owned by companies and those owned by sanitary authorities. Conditions as to notice and restoration should be exactly the same for both. Railways should be made to maintain raised approaches to level crossings, as they have to do to bridges. The custody of Turnpike Trust papers, and still more of parish awards, should rest with the County Councils.

Colonel Hacking suggested that instead of one Bill there should be two, one dealing with road construction and maintenance, and the other with traffic and road regulation. He thought road users regretted the decision by which railway companies were relieved of liability of bringing bridges up to modern standards. In regard to traffic he thought the Ministry of Transport should be given more elastic powers than was at present proposed with regard to speed limits in certain areas.

Mr. Hunter, Stirlingshire, said the attempt should further be made to unify the law as between England and Scotland. He thought a suitable traffic Bill might be made to apply to both while highway law should be codified. Mr. A. Dryland, who followed, said before great improvement could be made there would have to be forthcoming readier methods of acquiring land and determining building lines. The time had passed when an adjoining owner should have any right over part of the highway. They needed more power as regards dangerous corners and hedges, &c. Half the cost of maintenance was due to trenching, and restoration should be made as sound as the road previously was. Deep ditches should not be allowed close to modern roads. Power should be given to fill in and pipe and take in the land so made.

Mr. Thomas Griffith, Glamorgan, said in the Rhondda district they were troubled with high maintenance costs due to mining. He would like to see the law changed so that royalty owners and people receiving ground rents should be reasonably rated for the upkeep of the roads so damaged. A plea for better village signs was put in by Mr. E. B. Martin, of Salford. In France, on the first house of every village the name was given, together with the classification of the road, and distances. They also wanted regulations to protect their roads after frost. The position of mains should be standardised under the road, when less damage would accrue from opening-up.

Major A. T. Davis, Shropshire, said they wanted more definite motor warning symbols and the powers to prevent colourable imitations being set up where unnecessary. Regulations should be applied to the whole country. He agreed with the naming of villages, &c. Farmers should be prevented from soiling the roads, hauling roots, &c., out of fields.

Mr. C. Durie, Wilton, Somerset, said he had had experience of the working of an Act putting the cost of topping hedges on the rates. It had worked well, and should be extended.

In reply to the discussion, Mr. H. H. Copnall said there was no statutory authority at present regarding the rule of the road. He thought the police should control the traffic everywhere. Records and parish awards should be procured where possible. Holders should be made to give them up under penalty. It was not reasonable to expect railway companies to rebuild railway bridges to meet some complete change of traffic without some compensation. Owners' rights might give trouble in rural districts. They no longer did so in urban districts. They should be abolished. On the point of extraordinary traffic he preferred a haulage rate to litigation. An arrangement could usually be come to, to pay such a rate before the traffic came on to the road.

The following resolution was then put to the meeting and carried unanimously:—"That this conference expresses its opinion that the consolidation and amendment of the highways law is a matter of urgent necessity, and approves generally the proposals made for that purpose by Mr. Copnall, together with amendments put forward by other speakers."

The meeting terminated with a vote of thanks to the author and the chairman.

(To be continued.)

MAGNETIC AND MECHANICAL TESTING OF IRON.

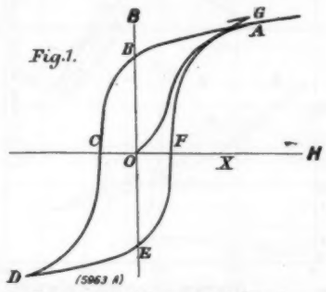
In spite of their antique associations magnetic phenomena retain their singular character. None of our senses respond to magnetic forces at all. The metals of the iron groups are practically alone affected by magnetism, and though the electronic theory may explain the complexity of magnetic phenomena, we do not understand why they are limited to so few of the strong and heavy metals of the engineer. All matter is subject to gravity; our senses remind us of it every moment. Mechanical stress, pressure, inertia, centrifugal force domineer over the inanimate as well as over the animate. Chemical forces, light, electricity, heat affect everything and everybody, and can only be borne within limits. But we may move about in an intense magnetic field without becoming in the least aware of it—unless we put on steel armour. We need not trouble about the shadowy "animal magnetism," though it may date back to ages more remote than the recognition of the peculiar properties of the loadstone. Magnetic cures are just as efficacious with painted wood and sham coils as with real magnets and current-carrying coils. If we possessed the iron nerves of the popular hero, moreover, we might have to complain about new extraordinary pains, and man might never have passed out of the stone and bronze ages into an iron age.

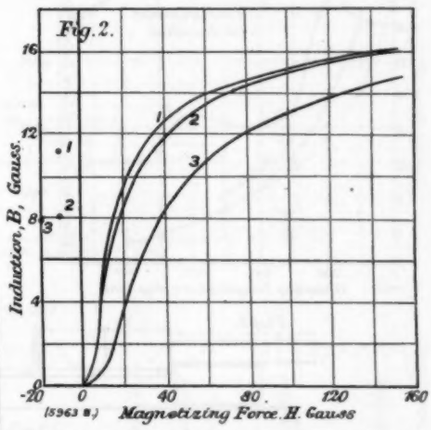
Strictly speaking magnetic phenomena are not singular, of course; for all substances are to a certain extent magnetic. But the gradations in magnetic properties are so steep as almost to isolate the ferromagnetic metals. We have long since learnt to utilise the magnetic properties of iron, and special methods of magnetic testing have been developed to assist

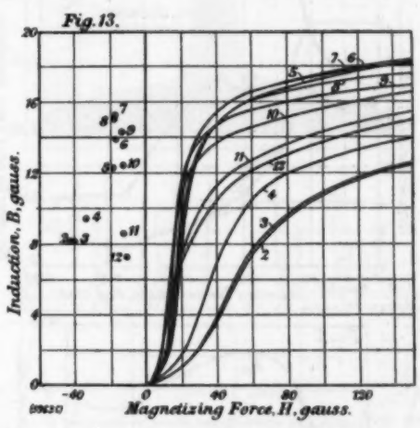
us in the selection of the proper material. So far these tests have been limited to magnetic purposes. Since, however, the magnetic properties are correlated with other physical properties, attempts have recently been made to substitute magnetic tests for mechanical tests. The engineer approaches such attempts with diffidence. He knows that magnetic testing calls for exact laboratory work. If the magnetic test could be transferred from the laboratory and from the prepared specimen to the mill and shop and to the finished forging or casting, he would welcome the new aid. But there the singularity and complexity of magnetic phenomena come in again, and the somewhat vague nomenclature does not facilitate their study.

The strength of unit pole, which repels (in a vacuum, and practically also in air) another unit pole at unit distance with unit force is also known as the unit quantity of magnetisation. The intensity of magnetic field is the force that unit pole will experience when placed in the field; this is also called the magnetising force, and is denoted by H and measured in gauss. If magnetism affected all substances in the same way, the effect of the field on any substance in it, the magnetic induction, could easily be predicted. But magnetism does not exist for air, wood and stone and most bodies; there are further, in addition to paramagnetic (ferromagnetic) materials like iron, which place themselves along the lines of force, axially between two opposite poles, a few diamagnetic metals, like bismuth, which place themselves equatorially at right angles to the lines of force, and the effect of a magnetic field on a magnetic metal depends upon many factors. To explain these relations it is customary to imagine that an excavation be made in a bar of the substance, which is placed in a magnetic field. When the groove is excavated along the lines of force, there will be no free magnetism on the opposite sides of the groove. When the groove runs across the lines, there will be free magnetism of opposite signs on the two faces, and the field due to the surface density of the magnetisation I on the two faces will be $4\pi I$. When the substance is isotropic and, only magnetised by induction, H and I will have parallel directions and the resulting induction will be $B = H \pm 4\pi I$, B being also measured in gauss*; the plus stands for ferromagnetic materials, the minus for diamagnetic. If we divide the equation by H, we obtain: $B/H = H/H + 4\pi I/H$, which is written $\mu = 1 + 4\pi k$. Here μ is the permeability, k the susceptibility; both these quantities are merely numerical factors; they are increased by vibrations, and may be increased or decreased by stress. With rise of temperature μ will increase until at the critical temperature of iron (about 700 deg. C.) the μ drops abruptly to zero, that is to say, the iron is no longer capable of being magnetised. A highly permeable iron will give a large B; but the μ is not constant for any material. It rises with increasing H to a maximum, which is attained already in a field of less than 10 gauss, then to drop off to a fairly steady value.

These relations are not simple, and there are further complications. The magnetisation depends upon the shape and length of the bar. The magnetic force seems concentrated in the poles near the ends of a bar, and the poles themselves exert a demagnetising influence upon the magnet. Bars bent to form an almost closed circuit, a horseshoe or ring, retain their magnetism much better than short straight bars. When the magnetism is excited by winding insulated wire round the bar, and the current sent through the coil is varied, other peculiarities are observed. As the magnetising current ($H = 0{\cdot}4\pi N I/L$, where N indicates the number of turns in the solenoid L centimetres in length carrying I amperes) is raised, the induction B (Fig. 1) rises in the curve O A, which becomes nearly parallel to the abscissa when H is about 150 gauss or 200 gauss. Supposing we have been tapping the bar all the while; then on decreasing the current, the B will go back on the same curve O A. If we do not tap the bar, then the induction curve will take the path A B C D, that is: when H is down again to zero, the induction will not be zero, but will have the value O B; when we reverse the current, the induction falls to zero at C, changes sign and attains a negative maximum at D; when we decrease the (now opposite) current, the induction will once more rise in the curve E F G, finally almost coming back to A. The loop described is not complete, but becomes more complete on our repeating the cycle. Thus the induction lags behind the decrease of magnetising force, and the loop is hence called the hysteresis loop. In Fig. 1, O X represents the $H_{max.}$, and X A the residual induction B_r; to reduce this residual induction to zero requires the reversed magnetising force O C, called the coercive force. As the coercive force H_c seems to impede the free movement of the molecules of the iron, it is also styled "magnetic hardness"; H_c increases with increasing H up to certain limits; for pure iron H_c is only a fraction of a gauss, for hard magnet steel it may have the value 60 gauss or 80 gauss, which is exceeded in special steels.







The questions now are: Are the magnetic properties of commercial iron sufficiently uniform, and is their interpretation sufficiently definite to reveal mechanical defects in the metal by irregularities of the magnetic tests? Can such tests be applied to entire work pieces such as rails? The interpretation of the test results is a difficult problem even in the mechanical testing of specially-prepared specimens, and one hardly expects that the questions will be answered in the affirmative. The evidence brought before last June's annual meeting of the American Society for Testing Materials, when discussing "Magnetic Analysis," was, however, of a decidedly promising character. The magnetic testing of cutlery and drills, of steel rails, rifle barrels, and ball-bearing races, largely tested as supplied, has satisfactorily proved the utility and practicability of the method; the nature of certain failures in rails has been disclosed, and our knowledge of the thermal treatment has considerably been extended. The meeting discussed five papers; the first of these came from the United States Bureau of Standards, which has taken the lead in this field, and we will, in the first instance, deal with this general contribution to the problem by C. W. Burrows and F. P. Fahy and their more familiar thermal work.

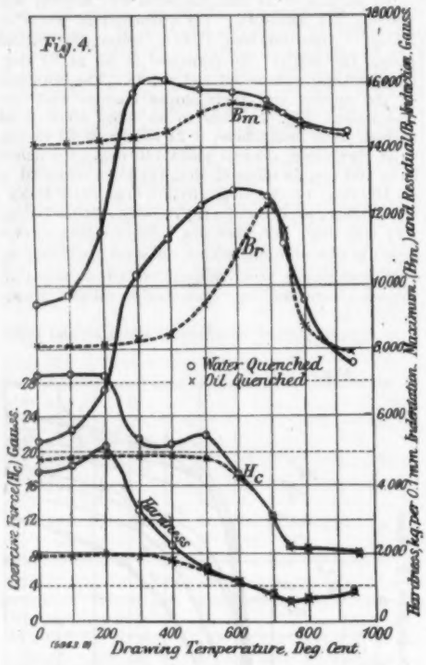
The thermal work was done in the usual way with the Fahy permeameter on prepared specimens of 10 in. by $1\frac{1}{4}$ in. by $\frac{3}{8}$ in., of carbon steels and alloys, which were tempered in various ways, quenched and "drawn," as it is called in America, that is, heated above the critical temperature, quenched in water or oil, reheated, and then slowly cooled. The few curves which we select from a large variety represent the O A of Fig. 1, and in the small numbers and circles the points where the ordinate of residual induction would meet the abscissa of the coercive force, the maximum magnetising force H being always 150 gauss. The carbon steel of Fig. 2 (1·04 carbon, 0·34 manganese, 0·017 silicon) was tested: (1) Annealed; (2) quenched in water at 2 deg. C. from 665 deg. C. (i.e., below, the critical point, 720 deg.); (3) quenched in oil at 21 deg. from 810 deg. (above critical point). The sequence of the curves and their slopes change with the treatment. Fig. 3 refers to an alloy steel (0·64 carbon, 0·51 manganese, 0·21 silicon, 0·63 nickel, 0·58 chromium, critical point 740 deg.), quenched from 800 deg. in oil at 30 deg. (2), then reheated to (3) 100 deg., (4) 200 deg., (5) 300 deg., (6) 400 deg., (7) 500 deg., (8) 600 deg., (9) 700 deg., (10) 750 deg., (11) 800 deg., (12) 950 deg. Intersecting curves were likewise obtained with a rail steel (0·90 carbon, 0·41 manganese, 0·42 silicon), tested as received, annealed from 806 deg., quenched in oil and drawn to 700 deg.

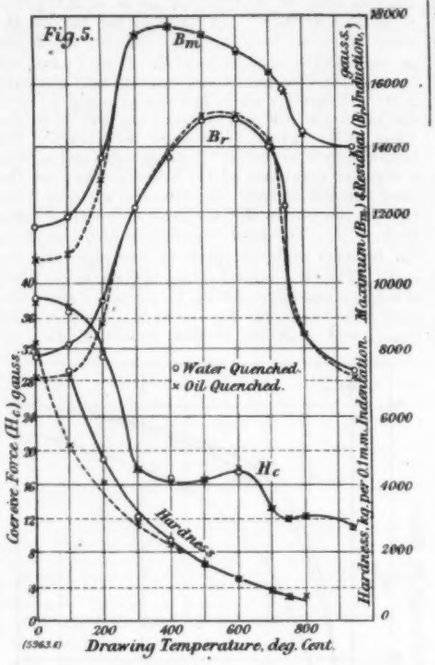
As regards general conclusions Burrows and Fahy point out that steel quenched and undrawn, and therefore strained, is not characterised by such abrupt changes in magnetisation as are to be found after drawing—the general inference hardly looks quite obvious from the data offered—and that with certain, possibly very significant, exceptions, the coercive force steadily decreases when the quenched material is reheated, while the induction increases within the same range up to a point near the critical temperature. To judge by the mechanical tests of the carbon and alloy steels we mentioned, reheating should (for use in spring construction) be carried up to 500 deg. and 600 deg. respectively; at those temperatures marked changes in B_r and H_c occur. The changes in the magnetic characteristics are not entirely consistent with the Brinell hardness. This Burrows and Fahy partly attribute to the fact that the hardness is strongly influenced by the condition of the exterior region of the steel, whilst the magnetic tests bring out the integral value throughout the mass. We might perhaps submit that the relations are somewhat as with ordinary photography, which reveals nothing but the surface, and with Röntgen-ray photography, which discloses the total mass at any vertical cross-section. But we rather turn here to the considerations which C. Nusbaum offered in his paper on "Certain Aspects of Magnetic Analysis."

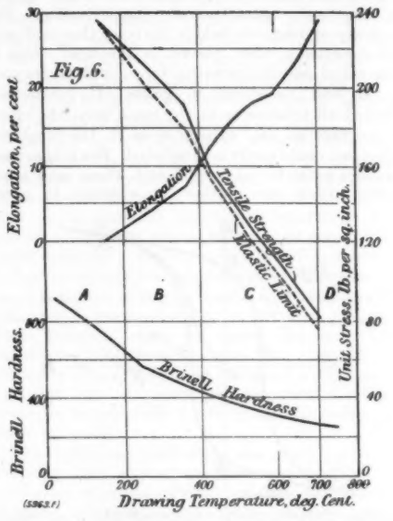
Having referred to the recent work of Honda and Takagi, discussed in recent meetings of the Iron and Steel Institute, Nusbaum passes to the selection of the comparative criteria of magnetic and mechanical testing. His remarks concern particularly the two steels of Burrows and Fahy alluded to, the carbon steel (1·04 C., 0·34 Mn, 0·047 P, 0·038 S, 0·017 Si) and the alloy steel (0·64 C, 0·51 Mn, 0·013 P, 0·038 S, 0·21 Si, 0·63 Ni, 0·58 Cr). Figs. 4 and 5 summarise the

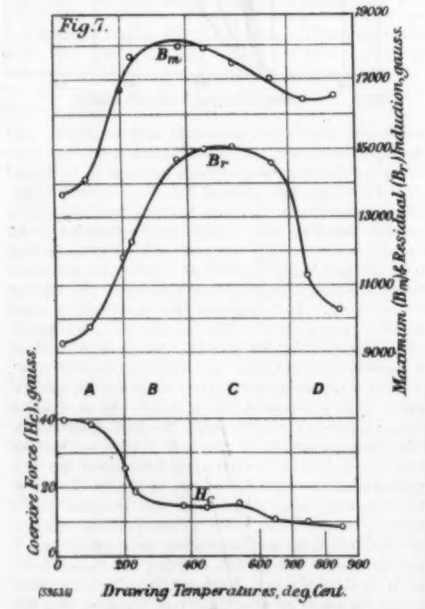
* Unfortunately perhaps; there is much controversy at present as to the desirability of expressing both H and B in gauss.

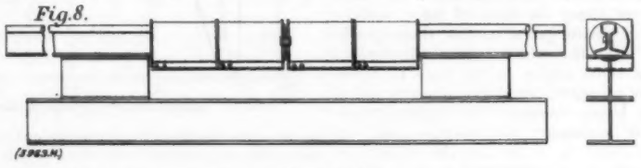
results of the magnetic tests and the Brinell hardness tests for the two steels. Nusbaum discusses these results with respect to the allotropic modifications, but we will confine ourselves to the more direct problem. The relations are evidently very complex, and general rules for the whole ranges of phenomena cannot be laid down. Nusbaum proposes a method of "limiting values" in the place of a direct comparison. The method is explained by the two diagrams, Figs. 6 and 7. In Fig. 6 (taken from

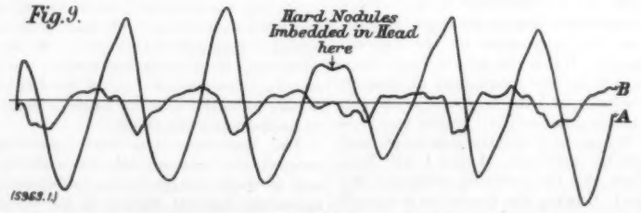










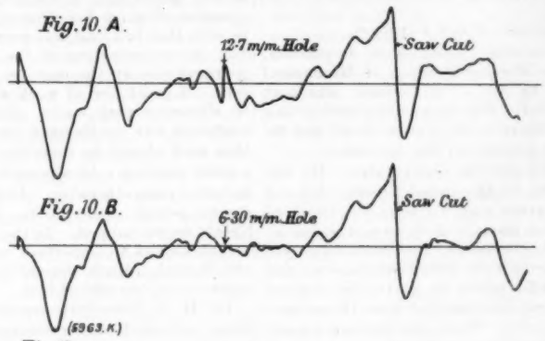


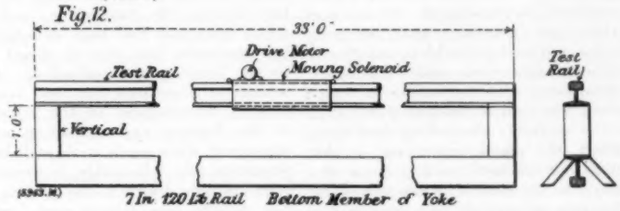
Bullen's "Steel and its Heat Treatment") the upper curves refer to a manganese steel for rifle barrels (0·45 to 0·55 C, 1·25 Mn); the hardness curve does not refer to the same steel (0·65 C, 1·32 Mn), but the difference is not important; Fig. 7 again concerns the rifle-barrel steel. The abscissæ are "drawing" temperatures, and the whole diagram is subdivided by ordinates into four regions A, B, C, D, roughly corresponding to the temperature limits for the hardened, tempered, toughened and annealed conditions of carbon steels after quenching and drawing. The method consists in choosing, from the three magnetic quantities determined at moderately high H (150 gauss to 200 gauss) two quantities which will definitely correlate these properties with the mechanical properties. One of these quantities will limit the properties of the specimen to one of the four regions, the second one will help to locate it. In region A the coercive force H_c has its maximum, but is decreasing, the B_m and B_r are minimal, but are increasing; for this region the H_c is decisive. In regions B and C, the H_c remains nearly constant and is hence unsuitable as a criterion; but the B_m and B_r admit of discrimination. Similarly in D any two magnetic quantities would define the mechanical properties. When the mechanical and magnetic properties resulting from a certain thermal treatment have been determined, it will thus be sufficient to submit products of similar compositions to magnetic tests, and suitable limiting values of the magnetic characteristics may be chosen to define the physical properties required. On such lines then a correlation of the properties is practicable.

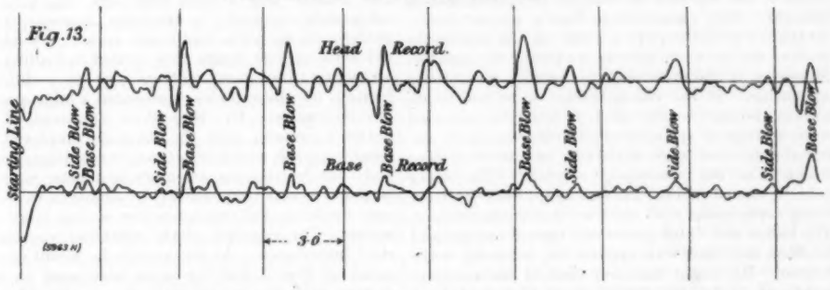
Applications. Cutlery. Drills.—Magnetic testing was first tried by Burrows and Fahy on knife blades and cutting tools. Knife blades must not have a feather edge, but should be both hard and tough, two properties not easily combined by heat treatment. Severe quenching may lead to cracking, the cracks not as a rule becoming visible until after grinding and polishing; "drawing" has therefore to follow quenching. Under-quenching may also occur. It was found that the proper hardness of the blade may be determined in terms of the coercive force, and this easy test, which does not mar the knife in the slightest degree, suffices for grading the knives. Knives likely to crack can hence be rejected before they have received the finishing treatment. Particulars of the tests were not communicated. Drills, it was stated, can similarly be tested by placing them against the test coil yoke of a Fahy permeameter (previously described in Scientific Paper No. 306, of the Bureau of Standards) and be arranged in their order of merit.

Rails.—The simplest method of magnetic measurements, the ring method, requires the preparation of a specimen, a ring wound with the magnetising primary, over which a few turns of the secondary winding are placed, in circuit with a d'Arsonval galvanometer. For bar specimens the permeameter is preferable. In the rail permeameter of Burrows and Fahy the magnetic circuit (Fig. 8) is built up of the rail, say 2 m. long, a corresponding length of heavy H-beam and two lengths of 35 cm. of the same beam connecting the rail and the yoke; the four coils indicated are in parallel, the test coil is placed near the surface of the rail with its axis parallel to the rail length. The leakage test is based upon the fact that the magnetic flux through a bar will not be entirely within the bar, but will partly leak out into the air, when the material is not homogeneous. The total flux is $\phi = \mu H A$, where A is the cross-section of the bar; it should be constant, but its determination is not easy. It is more convenient to move a test coil along the rail and to measure the time integral of the electromotive force called forth in a ballistic galvanometer with constant displacement; or to measure the rate of change of leakage with the aid of two test coils coupled in opposition to one another, which are kept at a constant distance of about 2 cm. while the whole apparatus, magnetising coil and test coils, move along the rail. One of the apparatus used for this purpose has only the one coil which slides over the test rail; the magnetic circuit is completed by very heavy beams of small magnetic reluctance. By these methods two rails were examined. The one, 30 ft. long, was a section of a 100-lb. rail—another rail from the same heat had caused a wreck—

the other consisted of 20 ft. of an 80-lb. rail which had itself failed and caused a wreck. The rails showed series of magnetically hard and soft spots, corresponding with the number of ties on which the rail had rested; the maximum hardness corresponded closely with the centres of the portions resting on the ties, these points being recognised from the local rusting of the rails. The nine tie marks of the second rail mentioned come out very clearly in Fig. 9; but it will be noticed that the curve A, obtained with one test coil, is not quite in accord with the curve B, obtained with two test coils; the arrow in curve A indicates the presence of hard nodules found embedded in the rail head, about





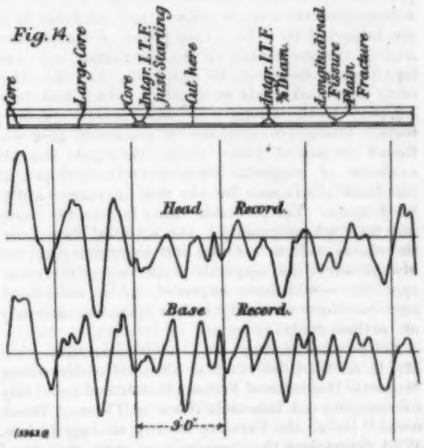


which nothing further is said. Fig. 10 illustrates some other features. By a saw cut purposely made across the rail head, 1 mm. wide, about 10 per cent. of the cross-section was removed; this saw cut was filled out with good transformer steel so as to simulate the conditions of a transverse fissure presently to be explained. Holes were further bored in the web of the rail. The saw cut is very distinct in the curves, and so is the 12·7 mm. hole in Fig. 10 (A); but the hole of 9·52 mm. (not reproduced) was far less distinct, and the 6·3 mm. hole of Fig. 10 (B) is quite indistinct, though attention was not drawn to these features by the authors of the paper.

The paper on "The Magnetic Survey of New and Failed Rails," by P. H. Dudley, of the Electrical Department of the New York Central Railroad, marks a very important development of these magnetic rail studies started by the Bureau of Standards. During the last decade interior "transverse fissures" in rail heads have given a good deal of trouble under service. Eight railroad companies reported 59 failures in 322,593 tons of rails from reheated blooms, and 1,054 failures in 559,644 tons of rails rolled direct. The failures were classified as "fatigue fractures," due to the wheel load, by the division of Safety of the Interstate Commerce Commission, which proposed the remedy of reducing the wheel load. When the railroad officials had collected the just-mentioned statistics, the cause of the failure seemed to lie in the want of homogeneity of the direct-rolled rails rather than in the excessive wheel load. Drop and tension tests, as well as cooling curves, meanwhile disclosed evidence of delayed transformation in the railhead, and the cores of abnormal metal formed might first be on the one side of the centre of the head, and then change to the opposite side within a few inches of length. Polyhedral crystals were found in the interior of rail heads; 132 rails were cut into small pieces, and crystals were observed in 22 of these. Fig. 11 illustrates an intergranular fissure in a 6-in. 100-lb. rail, rolled in January, 1911, in cold weather. There is a nucleus of central intergranular area, $\frac{1}{16}$ in. by $\frac{1}{8}$ in., surrounded by a lustrous zone in which fractures can be distinguished. The metal near the nucleus, numerous tests have established, is brittle and of low tensile strength and durability; under overload the nucleus fails suddenly as a whole These overloads occur at the mill. There the hot rails are sawed to length of 33 ft. 6¼ in. (to shrink to 33 ft.), cambered (the head curved round the base), and then run to the hot beds; as they cool, the base recalesces and is expanded round the head; then the head undergoes recalescence and expands round the base, more than the original camber. The cooled rail is never straight and must be "gagged" under the straightening press where impact stresses of 100,000 lb. per square inch are frequently imparted to the metal in the rail head. It is to this gagging, which sometimes completely fractures a rail, that Dudley ascribes the transverse-fissure mischief. To lessen it, the span of the supports in the press has been widened from 42 in. to 60 in. Reheating the bloom prevents the formation of the fissures, if carried to 1,260 deg. C., and this reheating had been the universal practice, but had largely been abandoned again; one mill, which has always reheated, has never had any transverse fissure.

When now the magnetic tests of rails displayed irregularities, the rails were broken, and checked nuclei from which interior fissures started were discovered. The apparatus explained by Fig. 12 was therefore constructed. The magnetising solenoid is driven at a uniform rate along the test rail by a motor which is geared to the brass drive roller. Two search coils (for separate head and base records), are placed within the solenoid; there are 10,000 ampere turns in the solenoid of 24 in. by 6 in. by 6¼ in., and currents of 4·7 amperes at 60 volts are used. Quite a thousand observations have been made on 60 new and 57 failed rails, and 217 photographic records have been obtained. A complete survey of a rail can be carried out in 25 minutes, half of that time being wanted for handling the rails. The 60 new rails will be kept under observation. We reproduce two of the leakage curves obtained. The rail of Fig. 13 was a new 6-in., 105-lb. rail; the span of the straightening-press supports was 42 in. The blows had been applied to the head or base or from the side; the oscillations in the head and base records are always similar, but the base records

Fig. 11.



are consistently lower than the head records, no matter whether the straightening blow was on the head or base. The side blows have distinctly smaller effects. Everywhere the greatest oscillations coincide with the positions of maximum overstraining, these positions having previously been determined at the mill. When the span was 60 in., the oscillations (not reproduced) were smaller. The old, failed, 6-in. 100-lb. rail of Fig. 14 shows similar, but greater oscillations. The positions of the gagging blows were unknown in this case, but the locations of the internal flaws and transverse fissures were subsequently confirmed by destruction drop tests. Dudley concludes that the magnetic survey furnishes valuable information not otherwise obtainable; and he would have these surveys conducted by the railway companies, not at the mills. The railroads themselves require so many different grades of steels for axles, crank-pins, tyres, wheels, rails, &c., that they could, he considers, best develop suitable magnetic testing methods for the present, at any rate.

In the magnetic testing of Ball-Bearing Races, by R. L. Sandford, of the Bureau of Standards, and M. F. Fischer, of the Hess-Bright Manufacturing Company, use was first made of a Dubois electromagnet provided with two arc-shaped electromagnetic limbs and special pole pieces, and of a

ballistic galvanometer, the throw of which is a measure of the coercive force. This is not a workshop method, however, and it did not reveal cracks and soft spots. Rotary hysteresis measurements have, therefore, been substituted. The same electromagnet is mounted on a horizontal base which is turned in ball bearings at 100 r.p.m. or 200 r.p.m., the race being suspended by a self-centring holder within the pole gap. The measurements depend upon rotary hysteresis, the torque which the field exerts on the specimen, and this method indicated the presence of flaws which the subsequent breaking up of the specimen revealed by rust marks. The account of these experiments is preliminary; attempts to produce a rotary field by a three-phase electromagnet did not answer, the high-speed rotation masking the flaws. But the rotary method is considered suitable.

In the paper on "The Location of Flaws in Rifle Barrels," finally, R. L. Sandford is associated with W. B. Kouwenhoven and the Ordnance Department of the Army and the Winchester Repeating Arms Company. A non-destructive test of barrel steel, to precede the drilling, for pipes and enclosures would manifestly be of great value, and the research at once disclosed, by the magnetic-flux uniformity test, the presence of an unsuspected grave flaw, like a burst blister, in a barrel steel. But, Sandford admits, the interpretation of the results is a very difficult matter. For the study of barrel steel a special apparatus was designed; the solenoid, suspended by cords, slips down and up the barrel, which is clamped in a vertical position between three steel pipes, the pipes completing the magnetic circuit. The speed of travel is about half a foot per second; the galvanometer period should be about 1 second, and either two search coils, or three mounted symmetrically, are used. Two kinds of particular tests have been conducted. For the one a homogeneous steel is chosen, and artificial flaws are imparted to it by fixing pieces of transformer iron of various shapes to the bar; thus, *e.g.*, bad longitudinal flaws can be imitated. For the other tests some bad steels were taken, which had been rejected on the strength of unsatisfactory drilling tests. Though no evidence of suspected pipe was found in any of these steels, they gave decided evidence of magnetic inhomogeneity, and proved too hard afterwards for the drill in magnetically-hard spots. Yet there are many factors favouring magnetic inhomogeneity; the artificial flaws mentioned, as well as bending and hammering, do not always affect the magnetic properties at the exact spot one would have expected to be influenced, and Sandford naturally insists upon the necessity of further study.

Before concluding we should mention that Mr. L. A. Wild described a "Method of Measuring Magnetic Hardness of Ferrous Metals and its Utility for carrying out Research Work on Thermal Treatment," before the Faraday Society on July 14 last. Wild determines the coercive force with the aid of a ballistic galvanometer on specimen rods, 3 in. long, $\frac{1}{2}$ in. diameter, within 2 minutes, and he brought before the meeting the results of a great many experiments on carbon and alloy steels, tempered, matured and refined, as he called it, for distinctive purposes, in water, oil, air under different conditions. His comparison with mechanical properties is mainly based on the scleroscope. We cannot go into details; but his recommendation that the magnetic test should find adoption in the metallurgical laboratory for deciding the merits of different methods and materials for quenching and heat treatment certainly deserves attention. The other communications we have noticed prove that magnetic testing may undoubtedly render useful service even in the workshop and mill, and the importance of the subject and the advantages of the method will appeal to the engineer, though he may feel dubious as to the interpretation of the results. The chief point of the method—that it can be applied to the finished or the semi-finished product, leaving it intact, and does not call for the preparation of specimens—is certainly very much in its favour. Much time and labour can be saved if we can find out the unsuitability of the material at an early stage in an easy way. The design of suitable apparatus does not involve exceptional difficulties.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An ordinary general meeting of the above Institution was held on Friday last, the 21st inst., at the Institution Building, Storey's Gate, Westminster, the chair being taken, in the absence, through illness, of Dr. Hopkinson, the president, by Mr. Mark H. Robinson, vice-president. The chairman, after expressing regret at the cause of Dr. Hopkinson's absence, congratulated the members on again being able to attend an ordinary meeting at their own house. There were some reparations still needed, and the library and reading room were not quite ready for occupation, but would be so shortly.

Mechanical Road Traction.

The formal business having been despatched, a paper on "The Present Position of Mechanical Road Traction," by Mr. C. G. Conradi, was next read, and discussed. We commence printing this paper in full elsewhere in the present issue, and we therefore at once proceed to the discussion.

Mr. L. A. Legros was the first speaker. He had found a few faults in the paper, chiefly those of omission. The author had, for instance, failed to give full reference in the case of the report issued by the Massachusetts Institute of Technology, yet many people, desiring more data than those quoted in the paper, would prefer to go to the original report. Mr. Conradi had touched upon the subject of the four-wheel drive. This drive had had a great vogue in America for heavy transport. It was very useful where the country was more than ordinarily hilly. It was a form of transport which, he believed, was likely to increase rather than remain stationary. Mr. Legros joined issue with the author in regard to chain tractors. The vehicle illustrated on Fig. 22 of the paper was certainly one which had every conceivable defect, the plates separating, so that they could act as nut crackers, coming down at a considerable angle to the ground, while the return chain at the top was not straight or approximately straight. This return chain had a reverse curve, so that it would require a guide on the top of the plates, which were already awkward to manage. Moreover, it had other defects, notably the absence of springs. If the chain tractor were not to do serious damage to the road, it must be provided with springs or spring-truck frames, so as to distribute the load more uniformly on a road surface which was not absolutely a plane. The other vehicle, shown in Fig. 23, was again very far from being comparable with ordinary American practice. The motor and clutch gear were exposed to wind and weather, and there was, apparently, no spring in the tractor. He might mention that in the developments of tanks, the latest mark that had been brought out was capable of travelling at 17 miles an hour, and that was achieved because the springs enabled the chain to be pressed on to the road or surface of the ground at different points along its length. He agreed with the author that the use of chain tractors for agricultural purposes was hampered by the restrictions on road travelling imposed on such vehicles. In some cases road travelling was allowed, and he would mention the case of a 75-h.p. Holt vehicle, which was permitted to travel on the country roads, when going from one farm to another, provided the spuds were not used while travelling.

Mr. Conradi had referred to the elimination of the differential. The invention of the differential dated back nearly a hundred years, and was first brought into prominent use by Starley. The figures which the author had tabulated showing the loss of power which resulted from locking the differential were of great interest. As far as he knew they were the first figures which had ever been published showing this loss as determined by experiment. It was useful to remember that the 7 per cent. to 12 per cent. of power lost was entirely expended in wearing out the tyres. Reference had been made by Mr. Conradi to the collection of goods, with a view to their despatch in common lots. As a railway man, the author would probably be aware that, on the Continent, a large business was done in grouping goods, arrangements being made for collection from the different countries, the goods being put into definite wagons, which were sealed, so that they might go through the customs frontiers of intermediate countries; this applied particularly to Switzerland. He thought it probable that something similar might be adopted to avoid two great wastes, emphasised by the author, namely, that involved in the difficulty of finding a return load, so causing dead mileage, and that created by the time lost in stoppages.

Mr. Thomas Clarkson felt that the author had dealt rightly, in the main, with the mechanical possibilities of handling the load. The actual application of power in various types of vehicles had received a great deal of consideration, but engineers, he felt, would have to focus their attention on this question of quick handling of the load. It should be seen that full load was provided all the time the vehicle was operating on the road. Empty return journeys put up the cost per ton-mile by 100 per cent. A great deal of work would have to be done to eliminate that waste. Some form of clearing exchange was, he thought, inevitable, but whether this work should be done by the Government was a moot question; he was inclined to think it would be better done otherwise. As to types of propellant, steam, petrol or electricity, he could only touch lightly on the subject. In the paper that point was not treated as an important issue, and finality was yet distant. Much depended on the commercial aspect; *i.e.*, the cost of fuel.

Dr. H. S. Hele-Shaw reminded members of the three main problems connected with road traction, the loading, the locomotion, and the unloading. Great attention had been devoted to locomotion, but engineers had now to direct their ingenuity to the loading and unloading. In view of the wonderful inventions that had contributed to the present development of the vehicles, the neglect of the loading and unloading aspects was not surprising, since goods could still be handled in the primitive way. Recently, however, attention had been strongly drawn to the loading and unloading. The vehicle was a good tool, but one most inadequately operated; to engineers, however, it was pathetic to see a fine tool badly worked. With the old horse vehicle, hours were wasted in loading and unloading; but now, matters were on a different footing, for idle vehicles represented a large amount of idle capital. Dr. Hele-Shaw approved of the author's opinion that the methods employed for handling goods were in most cases exceedingly crude, and that few serious attempts had been made to employ the apparatus already available or to evolve new methods and machines for saving time and labour. The principle of the container was one of chief importance. As an example he would remind members that it had for years been used in connection with passengers' luggage on cross-Channel traffic. It was no longer necessary for the passenger to wait while the luggage was transferred piecemeal from railway truck to steamer; it was now lifted off in the container and dropped on board.

Mr. Gattie would no doubt be gratified to learn from Mr. Conradi that his scheme presented no difficulties from the engineering side, though requiring further consideration from the commercial and operating points of view. Mr. Gattie proposed to have all goods come into the city on containers, and to have them sorted and handled systematically. The subject under discussion, however, was the motor road vehicle, and in this connection, Dr. Hele-Shaw referred to the exhibition at the Agricultural Hall, as showing the progress that had been made in tipping wagons. There were, at that exhibition, all sorts of contrivances and ingenious arrangements for handling and shifting goods. One vehicle he had seen, for instance, might have a funeral hearse on it one day, and might the next day carry general goods. The speaker then referred to a desirable improvement in the way of running a vehicle gently at a slow speed, a reference prompted by the fact that he had learnt from one of the large funeral establishments at Manchester that the drivers had difficulty in keeping their motor vehicles at a suitable slow pace. This point illustrated the variety of operation required from motor vehicles.

Mr. Conradi had commented upon the importance of what he had called "barrows." All had realised the loss of time and labour which occurred in railway

station prior to the advent of electric trucks, which were able to move about, carrying large loads behind them, with only one man to operate them. Dr. Hele-Shaw had recently made acquaintance, through an advertisement, with a "transveyor," the equivalent of the American "jack truck." As Mr. Conradi had mentioned the Hardaker jack truck, he might pertinently explain the working of the "transveyor." This contrivance consisted of an inexpensive platform, which would rest anywhere, carrying the load for transference to the vehicle. In order to move the transveyor it was necessary to "jack truck" it, an operation carried out by running the truck underneath it and then raising the truck platform, which was done by pulling over a lever. This lifted the transveyor and the whole arrangement could at once be transported.

Mr. C. W. Stamper, whose experience had been in the handling of goods in quantities, from and on to motor vehicles, referred to his detachable body system or loading truck, from which the body could be transferred from lorry to loading truck complete with its load. He confirmed the author's remarks, to the effect that if goods were handled in some such manner much of the time taken—perhaps half to three-quarters of an hour—for a vehicle to pick up its load would be saved. He knew of big depots in which the average time of the vehicle in the depot worked out at three-quarters of an hour; if, therefore, the transfer of goods could be effected in a quarter of an hour, the half hour saved would represent approximately 7*s.* 6*d.* to 10*s.*, according to the class of vehicle and the amount of labour required to work it.

Mr. A. W. Gattie spoke next. He remarked that the economy of the clearing house method had two aspects. The first was the rapidity with which the load could be carried in a detachable container, removable quickly and smoothly. It did not matter whether the container were of the class mentioned by the last speaker or that referred to by Dr. Hele-Shaw. The South-Eastern Railway containers had rollers underneath them, and could be rolled off the truck. At Folkestone, however, the containers stood solid on the railway truck, the rollers only coming into operation when the containers were lowered into the hold of the vessel. The essential point was the removal of the container from the lorry in a minute or two, and that, after such removal, a previously-prepared container with its goods should be lowered on to the lorry, which would depart on its journey of distribution. Under present conditions it was not uncommon for vehicles to be detained at Smithfield for five or six hours. The London Parcels Delivery Company and Messrs. Carter, Paterson, also experienced considerable delay at the depot in exchanging an incoming for an outgoing load—a serious matter, in view of the value of the machine detained. Such delays would not occur with the clearing-house system.

In his early days the speaker had been an official of the Bank of England, and while there the clearing-house principle was forced upon his attention. Before the introduction of the Banks Clearing House, it was the practice, in an all-round transaction, for 40 banks to call upon each other, each bank calling upon the other 39. Each clerk carried a satchel loaded with cheques, and returned with a quantity which he had collected from the other banks. The multiplication of 40 by 39 gave 1,560 as the number of visits, involving time spent in short walks, opening and closing doors, &c. With the advent of the clearing house, the visits were reduced to 40, a saving of 97 per cent. Mr. Gattie pointed out that if so great an economy could be effected where the time of clerks was concerned, such an economy was of much greater value when dealing with the case of expensive motor lorries and sometimes goods. He had seen in a narrow street in the city, about 9 ft. wide, a number of horse wagons unable to move owing to the congestion, the goods having to be hand-trucked along the narrow pavement from the wagons to the warehouse. By the clearing-house method one motor lorry would be detailed for that street. Should it be necessary to unload the whole of the container at one place, it would be well to have a lifting or sliding device, whereby the load could be transferred bodily to the warehouse. In the printing trade this was regularly done. It reduced vehicle mileage enormously for a man to start from a centre and take all the goods for a particular street, thus avoiding the necessity of traversing, say, 20 streets to deliver goods at various places. Moreover, the man would be in the best position for making a collection of goods, since, in returning to the collecting house, he was going to the place whence goods could be despatched to all parts of the world. In conclusion the speaker believed that, on the system he proposed, the 100,000 vehicles employed in carrying goods in London could be reduced to 5,000 vehicles.

Mr. W. H. Patchell, member of council, remarked that Dr. Hele-Shaw's reference to a motor hearse reminded him that friends of his who wished to transport a large model from Glasgow to Edinburgh, finding passenger and goods trains out of the question, actually employed a motor hearse for their purpose.

Mr. E. Batten considered that had the author given the relative prices of fuels, Fig. 45 in the paper would have been of greater permanent value. He believed it would be generally recognised that road transport, from the engineering and mechanical side was in safe hands, and would continue to develop; general emulation among constructors would evolve the best type for efficiency. With regard to four-wheel drives, and the exception taken by Mr. Legros to Mr. Conradi's contention, the speaker did not think that any one experienced in road transport would wish to adopt the four-wheel drive, on account of the extra complication involved, at any rate with the internal-combustion type; with the electric type conditions might be better. Further, he did not consider anyone would willingly adopt any caterpillar type for road traction, although in certain cases they might be constrained to do so. He had been asked by a forage merchant whether he knew of anything which would fetch hay from the stacks in the fields, and had advised that only a caterpillar could pick up the hay. Mr. Batten then proceeded to comment on the great advantage to be derived from road transport in the way of taking people to the land, so removing the occasion for many farmers to describe as "bad" the land which they had difficulty in dealing with. He took this view largely because it was noteworthy that there was no talk of "bad" land near towns. Generally, Mr. Batten dwelt on the benefits that would flow from increased road traffic and from the provision of power and light along the main roads of the country.

Professor W. E. Dalby referred to the definite figures given by the author, in which comparison was made of the power of the vehicle with the differential locked and with the differential in proper working. In this connection he thought it would add to the interest if particulars were given of the kind of road over which the vehicle was run. In an experiment of the kind undertaken by Mr. Conradi, the saving per cent. might work out at almost any figure if the car were run in a circle, as there would be slipping all the time between the wheels if locked, with the result that the tyres would be very badly worn. A rough plan of the road would afford some idea of the number of curves. A note on the road surface—whether cambered or flat—would also add value to the author's figures.

Mr. John Abbott called attention, in relation to the question of removing hay, to the pedrail, as a sound and workmanlike construction, which would, he thought, overcome many of the difficulties of the caterpillar tractor, in which gravel, for instance, was likely to work in between the many joints; Mr. Abbott did not share the fear of the four-wheeled drive expressed by previous speakers.

Mr. G. M. Junner suggested the relief of traffic congestion in large towns by the adoption of a clearing-house for passengers. With regard to tipping, the author had not, apparently, given any figures of time occupied in tipping particular loads. He had made a rough calculation of certain tipping gear, and found that something like 72,000 foot-pounds of work was expended in merely tipping the load, and one man was expected to tip a load in two minutes. Certain designs enabled the whole load to be shifted backwards on runners and then tipped, when on the balance; this seemed a much better arrangement.

Mr. S. T. Williams said that the importance of road transport in the Midlands had been brought home to him by a recent visit thereto. A hundred years ago the district depended on canals, and works were still found on the banks of these canals. The railway system in that part of the country was poor, and engineering works were constantly springing up outside the concentrated areas. Consequently, these works looked to road traction for conveyance of their raw material and the finished commodities. This prospective road traffic pointed to the necessity of bringing the efficiency of the roads into line with that of the vehicles. The asphalte road surfaces were not capable of withstanding the wear of fast-running motor vehicles, such as that of a 3-4-ton lorry racing along at 15 miles to 20 miles an hour. Mr. Williams also referred to the necessity of using high-quality material, properly treated, for axles and other vital parts of quick-running road vehicles.

The Chairman observed that the paper indicated a field in which the British engineer should be employed more largely than he was. The engineer had practically ousted the horse, but not the people working, so to speak, round that animal. It was evident that there was yet greater need of the designer and engineer, in the important, but little recognised, necessity for improvement in the handling of goods. The discussion seemed to be directed towards containers, and he hoped, in this connection, that the small article would not be lost sight of; not everything would go into containers. Dr. Hele-Shaw had referred to the containers in which luggage was swung from railway truck to ship's hold; but in that case the goods had one destination, some port on the other side of the water. Things had, however, frequently to be carried to many destinations in one vehicle, and the needs of the small article should be considered as well as those of the large one. He had prepared, more than forty-five years ago, working drawings for a steam lorry for delivering coal, and he had put in what was probably a novelty then—a crane, mounted upon the vehicle, which could swing out goods. He felt there were many cases in which that could still usefully be done.

Mr. Conradi then replied to the discussion. Mr. Legros had taken him to task with respect to the four-wheel drive, but he (the speaker) felt he must adhere to the opinions he had expressed in the paper; *i.e.*, that it was questionable whether conditions in this country were severe enough to warrant the extra expense in first cost and maintenance occasioned by the adoption of this design of vehicle, although it had much to recommend it in the case of heavy tractors. The general aim was the improvement of motor and other forms of traction, and the roads would doubtless be rapidly improved; therefore, he saw little need for the four-wheel drive. The extra complication must mean increase in maintenance cost. He thought Mr. Legros was really in agreement with the statement that vehicles constructed on the caterpillar or track-laying system were not likely to come into use for general purposes, and would no doubt be restricted to work on bad roads and rough lands, or for military purposes. The multiplicity of small joints in the best design of track-laying machine would put it "out of court" from the commercia standpoint; and whether or not a thing paid was the paramount question.

With regard to Mr. Clarkson's reference to organised road transport freight exchanges under a Government Department, he had meant, in the paper, to imply that the actual working should be left to the commercial people. To bring the latter together, however, there was but one quick way—a Government Department. Mr. Gattie's remarks only emphasised the need, which the speaker had endeavoured to indicate, for making use of all labour-saving devices. He might possibly join issue with Mr. Gattie as to detail arrangements, particularly outside the proposed clearing-house. In answer to Mr. Batten's request that the cost of the fuels used in connection with Fig. 45 in the paper should be given, he would say that the figures were: for current, 1½*d.*; for petrol, 2*s.* 6*d.*; and for coke,

THE PRESENT POSITION OF MECHANICAL ROAD TRACTION.

Fig. 1.

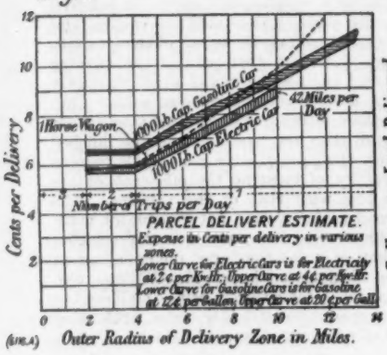

Cents per Delivery
1 Horse Wagon
1000 Lb. Cap. Gasoline Car
1000 Lb. Cap. Electric Car
42 Miles per Day
Number of Trips per Day
PARCEL DELIVERY ESTIMATE.
Expense in Cents per delivery in various zones.
Lower Curve for Electric Cars is for Electricity at 2 ¢ per Kw.Hr; Upper Curve at 4 ¢ per Kw.Hr.
Lower Curve for Gasoline Cars is for Gasoline at 12 ¢ per Gallon, Upper Curve at 20 ¢ per Gall.
Outer Radius of Delivery Zone in Miles.

Fig. 2.

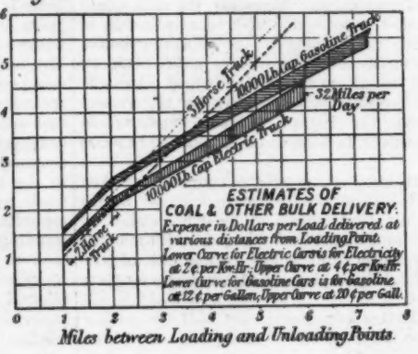

Dollars per Load Delivered
3 Horse Truck
10000 Lb. Cap. Gasoline Truck
32 Miles per Day
10000 Lb. Cap. Electric Truck
ESTIMATES OF COAL & OTHER BULK DELIVERY.
Expense in Dollars per Load delivered at various distances from Loading Point.
Lower Curve for Electric Carts is for Electricity at 2 ¢ per Kw.Hr. Upper Curve at 4 ¢ per Kw.Hr.
Lower Curve for Gasoline Cars is for Gasoline at 12 ¢ per Gallon, Upper Curve at 20 ¢ per Gall.
Miles between Loading and Unloading Points.

Fig. 3.

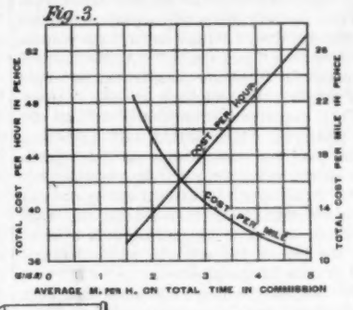

TOTAL COST PER HOUR IN PENCE
TOTAL COST PER MILE IN PENCE
COST PER HOUR
COST PER MILE
AVERAGE M. PER H. ON TOTAL TIME IN COMMISSION

Fig. 5. DEMOUNTABLE BODY HUNG FROM ROOF.

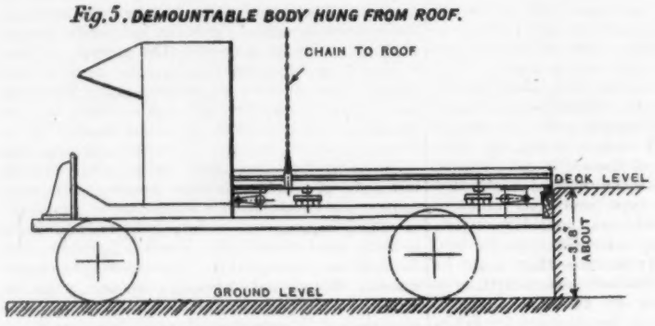


Fig. 6. CROSS SECTION OF STACKING FRAMES FOR DEMOUNTABLE BODIES.

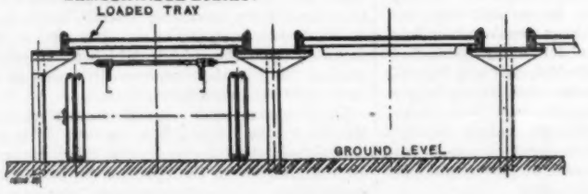


Fig. 7. DEMOUNTABLE BODY WITH LEGS.

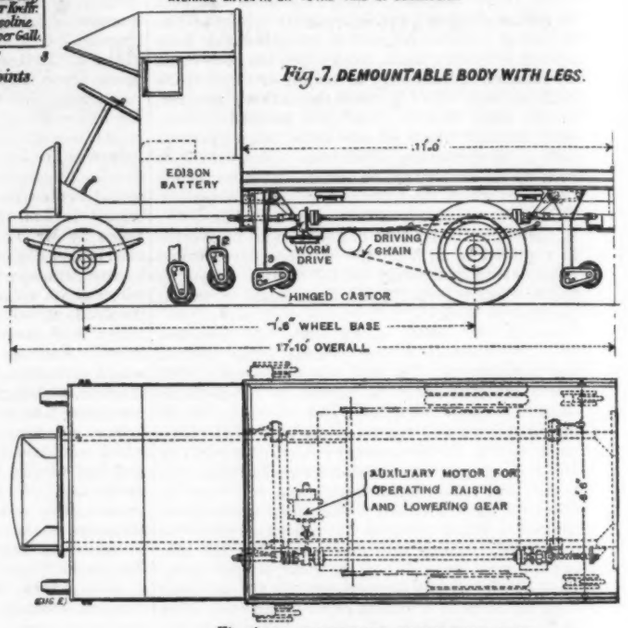
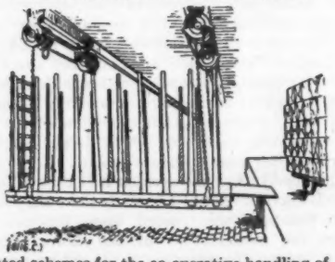


Fig. 4. PULLEY-BLOCKS SUPPORTING FLAT BODIES TO BE LOWERED ONTO VEHICLES.



30s. As Mr. Batten had pointed out, the four-wheel drive was readily obtained with the electric vehicle. With regard to the availability of electric current, if Mr. Batten would refer to the map he would see that the roads, canals and railways ran more or less parallel, so that if electric supply were taken down the railways, it would not be far away from the main road arteries.

In reply to Professor Dalby, the tests on the locked and free differential were carried out over the same piece of road, by the same driver, and, as nearly as possible, under exactly the same weather conditions. The speaker could put in a diagram showing the route and the number of turns, right and left. The tests were carried out in dry weather with practically no wind. The greater proportion of the road was of tar macadam with a very good surface. As a matter of fact, he had tried, after completion of the tests, to turn round in a circle, and broke the live axle in so doing. Replying to Mr. Junner, the author said the power and time taken in tipping loads was not a vital one; usually a 1-h.p. motor was required and the time occupied was about three-quarters of a minute. In the hand-operated gear the speaker had alluded to the load was run out to the rear of the vehicle, until it was practically balanced; it was then tipped under control of toggle levers. A man could easily operate that gear and tip a load of five tons in two minutes.

The Chairman, Mr. Mark H. Robinson, then closed the proceedings, announcing that arrangements had been made for reading and discussing Mr. Conradi's paper at Manchester on Thursday, the 27th inst., and also at Sheffield on Friday, November 28th.

THE PRESENT POSITION OF MECHANICAL ROAD TRACTION.*

By C. G. Conradi, of Derby, Member.

Transport of all kinds has become of such overwhelming importance to all members of the community, both individually and collectively as affecting the welfare of the Empire, that no apology need be made for bringing the question of mechanical road traction under general review at the present time. All branches of inland transport, namely, railways, roads and waterways, are necessary to our national life, especially as regards the goods traffic and more particularly as regards the handling of the goods, apart altogether from the mere haulage of the same from point to point. The actual application of the power to the trains or vehicles on railways and roads is performed more or less in an efficient manner, and further progress is continually being made, if only slowly; but the methods employed for handling and carrying the goods are in most cases exceedingly crude, very few serious attempts having been made to employ the apparatus already available or to evolve new methods and machines for the saving of time and labour.

Comparisons between haulage by canal, rail or road, are frequently made nowadays, but surely the correct conclusion is that each has its sphere of usefulness, and efforts should be made rather to control the whole so as to prevent overlapping and consequent waste. The roads, with which we are particularly concerned at the moment, would naturally, one would expect, act as feeders to the other two systems, and it is also on the roads that short-distance traffic would be carried. Where full loads can be obtained, the road vehicle working direct from door to door, with the consequent elimination of handling, is bound to score heavily over the railways on the shorter hauls, and under certain circumstances even on long hauls. A regular service, for instance, already exists between Nottingham and London, Birmingham and London, and between Lancashire and Yorkshire towns, whilst various Chambers of Commerce have formulated schemes for the co-operative handling of the traffic of their members by means of road transport. One of the great difficulties in the way of the economical operation of this traffic is the obtaining of full loads in both directions, and the constitution of freight exchanges becomes a necessity. A successful pioneer is that established by the Manchester Chamber of Commerce, which it is understood is now operated as a private concern, and similar bureaux should be set up in all the large centres with a view not only to providing a means of exchange between owners and users of vehicles, but of regularising the charges and co-ordinating the work of all such centres. It is probable that such an organisation would best be carried out by the Ministry of Ways and Communications.

Road haulage contractors are, however, soon involved in the same difficulties as the railway companies when miscellaneous traffic is to be dealt with, as terminals with large collecting and sorting accommodation have to be provided. Proposals such as have been put forward by Gattie for collecting and delivering miscellaneous parcels and goods traffic have much to commend them theoretically, but, although they do not present any difficulties on the engineering side, they appear to require further consideration from the commercial and operating point of view before any hope can be entertained of practical success.

There are two elements which constitute the system of road traction, namely, the roads and the vehicles which operate upon them. The former do not enter directly into the province of the mechanical engineer, and it is not proposed to deal with them here; but it

* Paper read before the Institution of Mechanical Engineers, on Friday, November 21, 1919.

may be noted in passing that the condition of the road surfaces affects very largely the economical operation of the vehicles, and therefore becomes a highly important factor in the national economy.

Engineers who have been dealing with the maintenance of motor vehicles during the last few years know how the increasingly bad condition of our roads and streets has swelled the total of failures and brought the repairs, costs and time-out-of-service up to abnormal dimensions.

The report of the Department Committee appointed by the President of the Local Government Board to consider the question of motor road traffic goes to show that not only has motor traffic undoubtedly done damage to the roads, but also that the roads are largely unsuited to withstand the wear and tear to which they are now subjected by this class of traffic, the obvious conclusion being that road engineering has not kept pace with the requirements of the times. It has also been shown that the damage done to the roads, excepting the case of those of water-bound macadam, was mostly due to the iron and steel-tyred traffic, which points to the necessity of equipping our vehicles as far as possible with some form of resilient wheel or tyre. The above-mentioned report gives certain information and recommendations as to speeds, axle weights, wheel dimensions, &c., and those interested may obtain copies from H.M. Stationery Office.

Animal Traction.—It is obvious that animal traction has a very limited field, and, on account of the low speed and small mileage possible per day, it must be confined to short hauls; although, on the other hand, its low first cost makes it difficult of replacement by mechanical haulage for certain classes of frequent-stop delivery work. When all expenses have been duly charged against animal traction, or, as we know it, horse traction, it has been found that in practically all spheres of operation it is more expensive and less efficient than motor traction, its best relative performance being as indicated above in very short haul traffic with numerous stops, a service which is suitable to its low speed and radius of action. This can be readily understood, as the capital costs in the case of a horse and its comparatively inexpensive vehicle are low, whilst the repairs item is almost non-existent. Edison is reported as having characterised the horse as the poorest motor ever built, and credits it with an efficiency of 2 per cent., whilst the author finds that a heavy railway dray horse has an average thermal efficiency of slightly over 1¼ per cent. The displacement of horses, however, by motors should not be undertaken too lightly nor without a full investigation of each case and the proper appreciation of the necessity for the operation of motor transport on scientific lines so as to ensure economic success.

Much of the traffic congestion in our large towns is due to the slow-moving horse, and the only practical means of speeding-up the bulk is to eliminate the horse altogether from the most congested areas. This would no doubt come about automatically in course of time, but meanwhile the waste of time and energy continues. Slow-moving traffic might be prohibited from using the most badly-congested streets during certain periods of the day, and the stream might with very great advantage be made uniflow in the narrowest ones, as has been done in the case of tramways in some towns, and also at the front during the war, whilst the construction of subways to take care of cross streams would materially assist matters.

The present situation could also be considerably eased if traders could be persuaded to arrange to accept goods earlier in the morning, but it is recognised that they have substantial reasons for objecting to do so.

One frequently hears it stated that motors cannot compete with horses on short hauls, but this is not the fault of the motor so much as the method of application. The motor truck is a time-saver; it will carry the same or a greater load much more quickly than horses, but it is only a time-saver when moving. Hundreds of motor vehicles are not moving for as great a proportion of their time in commission as they should, and are therefore not as economical as they might be.* The diagrams shown in Figs. 1 and 2 have been taken from a report on road transport issued some time ago by the Massachusetts Institute of Technology, and are based on 100,000 individual observations and owners' records during a period of four years. The width of the cross-hatched areas for electric and petrol motors shows the effect upon total expense of variations in the charges for electricity from 2 cents to 4 cents per unit (1*d.* to 2*d.* = 100 per cent. variation) and in the cost of petrol from 12 cents to 20 cents per gallon (6*d.* to 10*d.* = 70 per cent. variation). Actual money results must now be modified, but the author's experience goes to show that the relative positions of the curves have not materially altered except by way of improving the position of "The Electric." It will be observed from these curves that the horse is shown to have a slight advantage over even

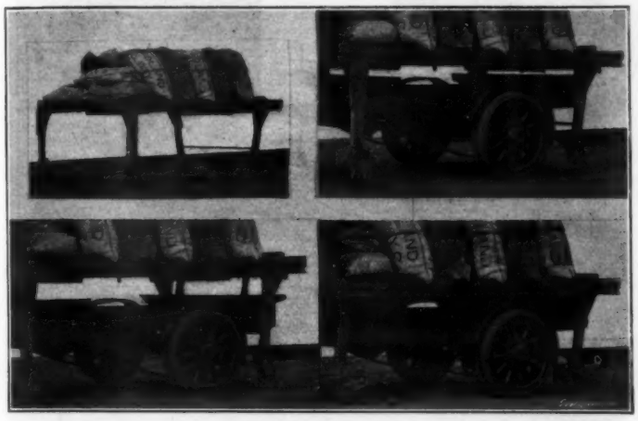


FIG. 8. LOAD ON DEMOUNTABLE BODY IN COURSE OF TRANSITION FROM GROUND TO ELECTRIC CHASSIS (EDISON) WITH SELF-CONTAINED LIFTING GEAR, OPERATION COMPLETED IN 2¼ MINUTES. (FOR DETAILS OF LIFTING GEAR, SEE FIG. 7).

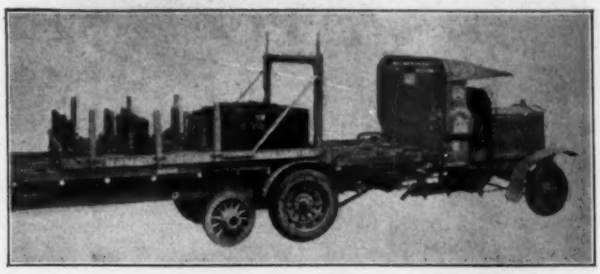


FIG. 9. 3-TON LOAD BEING TRANSFERRED TO MOTOR LORRY FROM LOADING TRUCK. (STAMPER.)

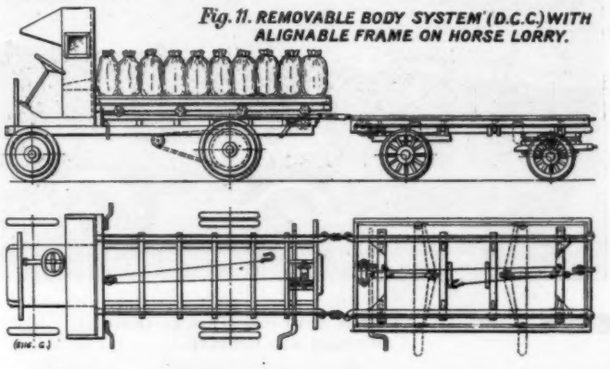


Fig. 11. REMOVABLE BODY SYSTEM (D.C.C.) WITH ALIGNABLE FRAME ON HORSE LORRY.

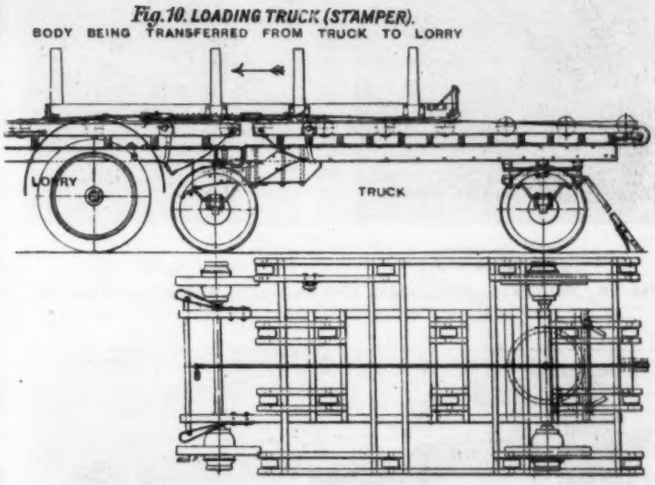


Fig. 10. LOADING TRUCK (STAMPER).
BODY BEING TRANSFERRED FROM TRUCK TO LORRY

FIG. 12. LOAD ON D.C.C. BODY IN COURSE OF TRANSITION FROM 4-TON LORRY (EDISON) TO TENDER LORRY, OPERATION COMPLETED IN 2¼ MINUTES.

* L. Brockman, "Self-Propelled Electric Vehicles." Trans. Institution of Engineers and Shipbuilders in Scotland, January, 1917.

the electric vehicle on the heavier work within a radius of 2 miles, but better methods of operation can reverse this position in the majority of cases.

Time lost in loading and unloading is responsible in almost all cases for motor inefficiency and for the fact that in some instances the cost per unit delivered is greater than with horses. Great waste takes place annually because users have not installed modern time-saving devices in connection with their motor service, and it should be recognised that motor traction cannot be made a commercial success if it is still to be operated on horse-pace methods. In too many cases the same methods of loading and unloading as obtained with horse haulage are continued when a change to motor haulage is made, no cognisance being taken of the fact that the high standing charges of the motor are still going on whilst it stands idle, and that it only makes money if saving time and therefore if moving.

The comparatively high capital cost of all mechanically or electrically-propelled vehicles and the shortened working day necessitate the fullest use being made of them, and advantage should be taken of all accessory apparatus which will cut down the time lost in loading or unloading or enable the vehicle to carry a greater load.

Cost of Mechanical Traction.—A normal day's work of 10 hours for a vehicle used in town delivery work may be analysed as follows: Running 3 hours, meal 1 hour, loading 3½ hours, unloading 2½ hours, from which it is seen that by saving even only 1 hour out of the two latter items the running time (which is the true money-earning portion) can be increased by 30 per cent. Such savings can be more easily realised perhaps by taking the actual case, say, of a 3½-ton vehicle costing 1,000*l*. The capital and driving charges of this machine would amount to roughly 300*l*. per annum, or 2*s*. 6*d*. per hour whether moving or standing, to which must be also added the loss in earning capacity. Fig. 3, page 714, shows the effect on cost per mile of increasing the miles

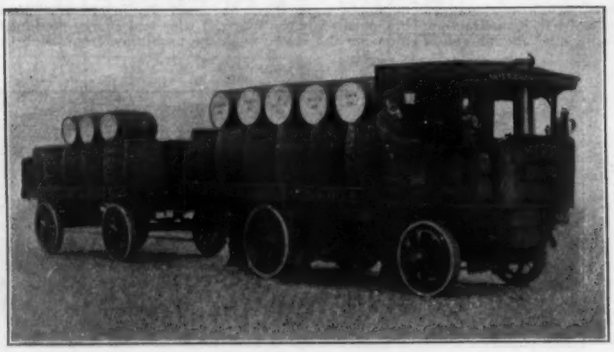


Fig. 13. 6-Ton Wagon and Trailer (Sentinel).

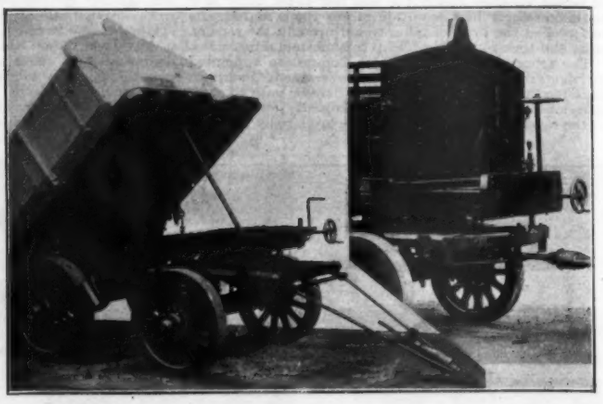
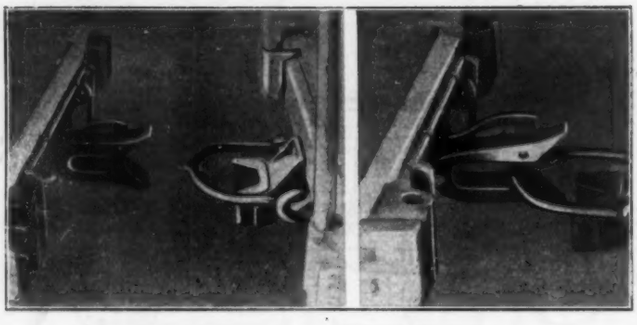


Fig. 14. Tipping. Fig. 15. With Steering Gear. Trailers (Bristol Wagon Co).



Cars Separated. *Cars Coupled.*

Fig. 16. Automatic Coupler in Use on Small Warehouse Trollies.

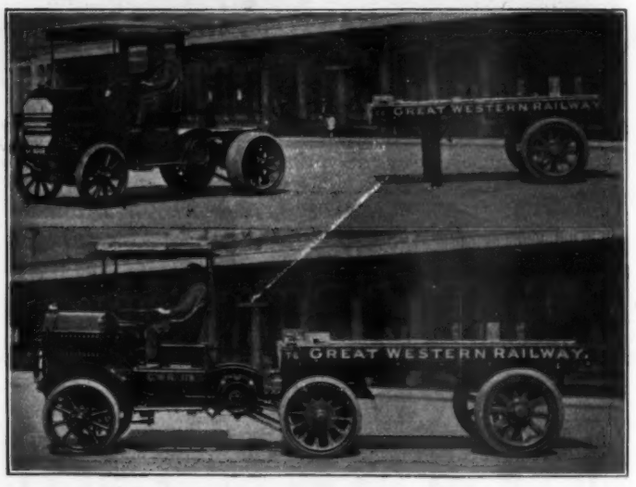


Fig. 17. Tractor, with Semi-Trailer (Knox). Uncoupled and Coupled.

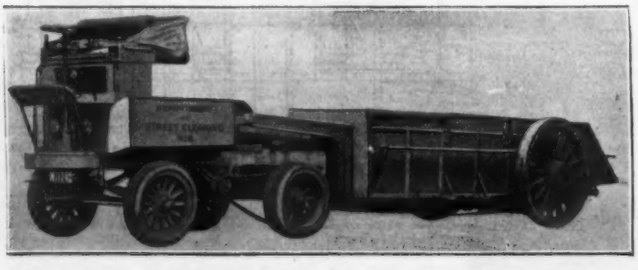


Fig. 18. Street Cleaning Tractor and Semi-Trailer (G. V. Co.).

Fig. 19. 4-Wheel Refuse Wagon, drawn by Electric Tractor (Lloyd), with Rear Wheels Lifted off Ground.

Fig. 20. 40-H.P. Thornycroft Type Indian Lorry, with 2-Wheeled Trailer.

run per day or the average miles per hour taken on the total time in commission, that is, without lengthening the working day, but by decreasing the standing time, the vehicle is made to do more work, and the standing and driving costs are therefore spread over a greater mileage.

The engineer is still, however, helpless in the face of existing haphazard methods of operation where "waiting turn" at docks, warehouses, &c., is still in vogue, with consequent idleness and waste of time. Pooling has been proposed, and with it there apparently comes the necessity of standardisation, to a certain extent at least, of body design, floor height, &c., whilst the possible use of removable bodies should not be lost sight of. Various means have been proposed for increasing the efficiency of motor traction, and an examination of these might prove useful.

Time-Saving Devices for Loading and Unloading.—Since the average vehicle loses more time at the loading point than at any other part of its route, devices which assist rapid loading are perhaps most numerous. Removable bodies or variations of the demountable principle are probably the most effective of such devices, and isolated cases have been in use for a considerable number of years. The "Lancashire" flat, for instance, as used for concentrated heavy loads of linoleum and cotton goods, and lifted off by the ordinary goods yard cranes has been in operation for at least twenty years, whilst removal contractors have made use of the system by arranging for the bodies of their pantechnicons to be made detachable. It is obvious that if an extra body can be left at the loading dock to be dealt with whilst the vehicle is out on its round and satisfactory means are provided for changing the bodies, the delay to the motor will be reduced to a minimum. It will usually be found sufficient to employ three bodies—one loading, one in transit on the vehicle, and one unloading at the other end of the route.

A simple arrangement illustrated by Fig. 4 is to provide plain flat bodies and sets of pulley blocks which are suspended from the roof of the warehouse, and for men to lower the bodies on to the vehicles when these have been backed into position. The Curtis Publishing Company are reported to have increased their haulage per day on four vehicles by 14 tons by this means, which, however, is open to the objection that a considerable amount of labour is required for lifting and lowering the bodies. This arrangement is also only applicable where a strong roof or overhead structure is available whilst the lifting gear confines the loading to fixed points and would have to be provided for each body in use. An improvement on this was designed by the author some time ago in which the lifting gear was embodied in the motor chassis, the lifting gear then being always available irrespective of position, and the bodies were supported at one end by sling chains from the roof and at the other on the edge of the loading deck, as shown by Fig. 5, page 714. Where the roof is strong enough to carry the weight, and there is no necessity to move the bodies from the loading point until required by the motor vehicle, this is a very satisfactory method and much the quickest in operation. If it is necessary to move some of the loaded bodies to provide space for others, they can be accommodated on stands, as shown by Fig. 6.

In an extensive system using such an arrangement of body, a cheap slow-speed electric vehicle which might be designated the conveyor, and used to lift, convey and deposit the bodies as dealt with, could in the case of railway transport supply the link between the wagon and the road vehicle without any upheaval of existing methods or the provision of expensive machinery and buildings. Full loads between stations would be dealt with on the same bodies, but by employing overhead cranes for the transfer from rail to conveyor or road vehicle.

A further modification, and one used where no means exist for supporting the bodies, consists of providing special legs with hinged feet which are turned up out of the way to give road clearance when travelling. Fig. 7 shows such a body as fitted to a 2-ton electric vehicle by the Edison Accumulator Company, whilst Fig. 8, page 715, shows the operations in detail of picking up a loaded body. The lifting gear is driven by a separate small electric motor which is arranged with an automatic cut-off to prevent overrunning. To provide for easy entrance of the chassis under the body, the front legs of the latter are made to pull out to give additional clearance (position 1, Fig. 7), and when pushed in to the normal position present no obstruction in traffic (position 3). The provision of lifting gear of this description allows the driver to discharge a loaded body and take on another in a very few minutes unaided and with no special exertion.

Several methods employing bodies which can be rolled off are in use; one, for instance, is that shown in Fig. 9, page 715, and Fig. 10, and known as the Stamper loading truck.* In this system at each end of the journey a truck or trolley is provided on to which the body is transferred from the lorry by means of a winch. The truck is arranged with a standard type of forecarriage and draw gear which enables it to be moved if desired. The truck has no springs, so that the height remains constant, and consists of a framework provided on the top with a number of rollers, a similar set of rollers being fixed on the motor chassis. The tail end of the truck is formed with sloping guide plates which engage with rubbing plates attached to the rear of the motor vehicle, so that when backed together their heights and that of the two sets of rollers are the same. A certain amount of play is also allowed on the axle arms to facilitate

* See ENGINEERING, March 30, 1917.

FIG. 22.

FIG. 23.

FIGS. 22 AND 23. TYPES OF CATERPILLAR TRACTORS.

Figs. 21 and 24 to 29. SKETCHES OF DEVICES FOR QUICK LOADING AND UNLOADING, ETC.

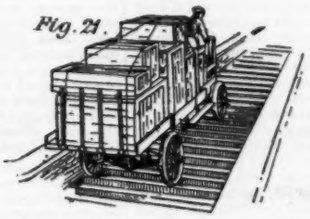


Fig. 21.

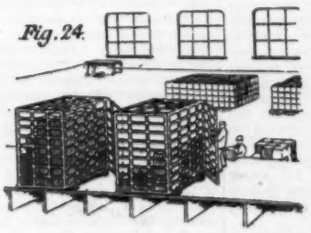


Fig. 24.

Fig. 25.

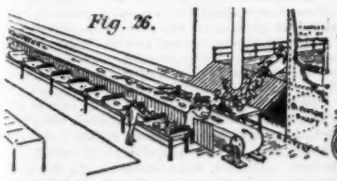


Fig. 26.

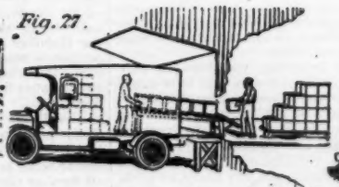


Fig. 27.

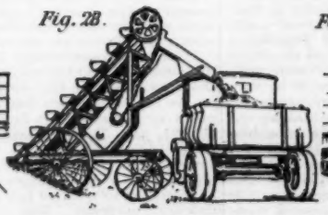


Fig. 28.

Fig. 29.

centring. On the under side of the body four angle irons are fixed lengthwise, which act as runners and prevent side movement. The method of operation is, for the motor lorry on its arrival at the loading point to back up to the loading truck so that the foot irons enter the guides on the rear of the truck, and on further backing taking place the foot irons slide up these, so ensuring that the two platforms are brought to the same height. By means of the winch on the motor, the body can then be drawn across into position where it is automatically locked as it passes over a pair of spring-operated bolts.

Another system, using tender lorries and designed with a view to obviating trouble in obtaining accurate alignment between the two vehicles for the transfer of the bodies, is that illustrated in Fig. 11 and Fig. 12, page 715, and known as the D.C.C. system, the inventors being Messrs. Dalziel. Crocker and the author. The main underlying idea in this case is the provision of a loose frame carrying the body, and which can be twisted in any direction or traversed across so as to bring its rails into true alignment with those of the other vehicle, the two vehicles having previously been only approximately and quickly placed in alignment. The rollers in this system are fitted to the bodies, which run on rails carried by the vehicles, whilst disused horse lorries are generally made use of as the tender vehicles. Short telescopic rails connect the two vehicles and the rails on the tenders are formed into loose frames carried on rollers and controlled by levers and chains from either side. In this case after the vehicles have been roughly positioned and the connecting rails dropped into their sockets, one or both ends of the frame carrying the rails on the tender are drawn across until the rails are in alignment with those on the motor vehicle. It will be readily seen that an operation such as this is necessarily much quicker and easier than trying to meet the same end by see-sawing the motor back and forward. A feature of the D.C.C. system is that the body can be taken off or put on to the tender lorry at either end, whichever happens to be handiest at the moment. With any of these foregoing arrangements, bodies can be exchanged in a few minutes, and an added advantage from the loader's point of view is that the loading can be carried out at his convenience and to the best advantage. In some cases it is desirable that bodies which have been dealt with should be removed from the loading deck to make room for others, and, when tender lorries are in use, this can be readily accomplished by a horse or cheap form of tractor. The warehouses and yards of private traders, however, may not allow of the use of tender vehicles, in which case the frames for alignment may be placed on the decks so that the bodies may form part of the floor space. By such an arrangement one of the objections to the Gattie system, namely, the difficulty of handling the containers at the average trader's premises, can be readily overcome.

Trailers.—What amount in effect to removable bodies are the trailers, semi-trailers and road trains, whilst they have the advantage under favourable circumstances of enabling a greater load to be hauled by the same power unit. Quite extraordinary claims have been made for the performance of trailers, especially in America, and no doubt for bulk loads and on easy routes they have their place, but the wholesale adoption of trailers behind ordinary vehicles carrying loads cannot be justified, as a trailer takes power to haul it, reduces the speed of working, accelerates depreciation of the mechanism, and increases tyre wear. In this connection the law regulating the construction and use of trailers has done much to limit their adoption, the main points to which exception may be taken being that the speed of a motor vehicle hauling a trailer must not exceed 5 miles per hour, and that it must not haul more than one at a time.

There is no reason whatever why trailers should not be operated safely up to 10 miles per hour, and this would at one sweep double the nominal capacity of the combination for doing work, and by fitting them universally with rubber tyres no more damage would be done to the roads. For bulk loads, trailers or road trains drawn by suitable tractors form a very economical combination, but their use in congested areas should be confined to night work. The tractors for such work must be specially designed, as they require to be very robust to withstand the sudden and violent strains to which they are subjected in starting and braking the trailing load, whilst in tractors of the internal-combustion type, as the power unit is run more nearly at full load for considerable periods than is the case in ordinary vehicles, particular attention should be paid to the cooling surfaces, and it is also usual in this type to provide more than the usual number of gear changes. A comparison between the full trailer and the semi-trailer is interesting as showing the work for which each type is most suitable. The full trailer, examples of which are shown in Figs. 13, 14 and 15, page 716, is a separate vehicle on four wheels, and can be more readily left for loading and unloading whilst the tractor is away on other work, but the combination has the disadvantage of being very deficient in manœuvring properties, especially in backing. This has been got over in trailers of the type Fig. 15, page 716, by the provision of individual steering gear and, when desired, forecarriages at each end which can be locked at will. In the one shown the draw bar is locked to the forecarriage by a pin, when being hauled forward, and the hand steering gear disengaged by means of the clutch seen just above the platform, whilst in backing the draw-bar is left free and the movements of the trailer directed by the hand steering gear. Trailers of this type can be readily adapted for use with tipping bodies as is shown by Fig. 14. It should be noted that draw gear for trailers should be constructed with double-action springs to take care of the starting and braking shocks.

Semi-Trailers.—With the semi-trailer the tractor partly carries and partly hauls the load, the front end of a two-wheeled vehicle being carried on a platform directly over the rear or driving wheels. About 40 per cent. of the load is usually taken in this manner, the remaining 60 per cent. being carried on iron-tyred wheels. A load of 10 tons can be easily dealt with by this combination without the truck having to be made excessively heavy, as it otherwise would be if designed to carry the total load, if that were feasible under axle-weight restrictions. Additional load on a semi-trailer provides additional adhesive weight, but never more than 40 per cent. of the total. The three-axle arrangement thus obtained is allowed to run up to 12 m.p.h.; it is more compact than the four-axle with two independent vehicles, and much easier to manœuvre, being somewhat on a par in this respect with a horse and lorry, although the side-stepping action of the horse can never be wholly equalled. By propping up the front end, the trailer may be left for loading or unloading, but this operation takes more time than the uncoupling of a four-wheel trailer, with which, however, there is always the danger of a man being crushed. For this reason some form of automatic coupling is advisable, which should then be arranged for release by the driver without his having to leave his seat. A coupling of this description in use on small warehouse trollies is shown in Fig. 16, page 716, and described in *The Railway Gazette*, of January 12, 1916. Some modifications of this design would be required to meet the higher speeds and greater weights encountered in road haulage.

A typical example of the semi-trailer combination is shown in Fig. 17, page 716, which is a Knox tractor of 7 tons capacity in use by the Great Western Railway Company. The tractor is so constructed that its chassis proper ends at the chain-drive sprocket cross-shaft; the rear axle is attached to this chassis through the medium of the radius rods and the weight of the rear end of the chassis is carried on it by the rear ends of two long cantilever springs. The rear axle and wheels are therefore an entirely separate unit so far as carrying the load to be hauled is concerned. A separate frame cross-braced and carrying a central pivot for receiving the semi-trailer pin is mounted upon two stiff semi-elliptical springs, which are in turn anchored to the rear axle. The front end of the semi-trailer is thus carried by the rear wheels of the tractor only; the more flexible springing of the tractor chassis proper remaining constant and independent of the load carried on the semi-trailer. The legs of the trailer hinge up under the body when the latter is in the running position. An electric tractor and semi-trailer refuse wagon, as made by the General Vehicle Company is shown in Fig. 18, page 716, the connection being made by a rocking fifth wheel and cone bearing on the tractor with the cup on the trailer. Fig. 19, page 716, shows an interesting variation of the three-axle arrangement with four-wheel tractor and trailer. This is a four-wheel refuse wagon drawn by a Lloyd electric tractor, which, after coupling-up, has its rear wheels lifted off the ground by means of a screw gear. Such a combination gives a three-axle machine with good manœuvring qualities, but necessitates a front-wheel drive and steer, which is obtained by fixing an electric motor directly to each front wheel which is driven by internal gear. This is the Mossay system used in the construction of the smaller-sized "Orwell" vehicles built by Messrs. Ransomes, Sims and Jefferies.

It has not been found advisable to use four-wheeled trailers with petrol vehicles for the reasons already given, but numbers of two-wheeled trailers have been employed for special military purposes, such as for the conveyance of aeroplanes, &c. Fig. 20, page 716, shows a Thornycroft lorry with standard body and two-wheeled trailer used by the Government of India. The trailers are used on the plains and the lorries alone in the hilly regions on the Afghan frontier. Another method which has been adopted to enable greater loads to be dealt with is the four-wheel drive, in which 100 per cent. of the weight is used to give adhesion for driving, instead of the 75 per cent. which may be considered as the usual maximum with the ordinary two-wheel drive.

It is very questionable, however, whether the conditions in this country are ever severe enough to warrant the extra expense in first cost and maintenance occasioned by the adoption of this design of vehicle, although it has much to recommend it in the case of heavy tractors. Fig. 21, page 717, illustrates the capabilities of a four-wheel drive petrol vehicle. Vehicles constructed on the caterpillar or track-laying system are not likely to come into use for general purposes, and they will no doubt be restricted to work on bad roads and rough land or for military purposes. The question of cross-country transport was at one period of the war of very vital importance, and as the tank construction was not suitable for such work, the tractor illustrated by Figs. 22 and 23, page 717, and known as the "Newton," was evolved. It was designed for mass production at a low cost, and had the war continued it would have been turned out to the number of some 20,000; its construction in quantity had, as a matter of fact, already been begun, and a few hundreds had been completed when the armistice was signed. The idea underlying the design was the utilisation of standard peace time material, such as conveyor chain links, motor-car engines, boiler plates, &c., all of which could be procured and produced easily in large quantities. These vehicles had a very low intensity of ground pressure, and with the addition of a few sand bags would have been capable of carrying men and materials quickly and comparatively safely into the enemies' territory over the worst of ground surfaces. Fig. 22 shows the first experimental tractor, whilst Fig. 23 shows it as finally produced. The objection for commercial work to all machines of this type constructed on the track-laying principle is the heavy upkeep due to wear and tear of the multiplicity of joints, a construction which does not appear to be readily capable of improvement. In cases where demountable bodies or trailers may not be applicable, other means may be utilised to assist in quick loading, such as overhead cranes and runways, spiral and straight chutes, conveyors of various types, and hand and electric baggage trucks with elevating platforms. Little need be said as to the details of these various devices which are familiar in other branches of engineering and contracting work. Figs. 24 to 29 are self-explanatory and illustrate the application of some of these aids to quick loading, most of which can be utilised for the reverse operation, namely, that of unloading.

(To be continued.)

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—According to representative manufacturers, there exists no bigger impediment to industrial progress than railway delay and wagon shortage. Information compiled by five of the largest iron and steel firms in Sheffield covering a period of one month, shows that the bulk of journeys that normally should be completed in 24 hours are occupying from two to fourteen days. One local manufacturer has had goods waiting six weeks for Glasgow, and in another case, three trucks of goods were actually despatched to Cleckheaton, and on arrival there the station refused to accept and the wagons were returned to the starting point. In view of the daily complaints made by South Yorkshire business men, the Sheffield Chamber of Commerce has made strong representation to Sir Eric Geddes, who has now promised a more efficient supply of empty trucks to the Sheffield industries. The position in the engineering trades gives cause for genuine anxiety. The prospect of an early settlement of the moulders' strike appears to have vanished, and with it the chance of securing valuable business. Works are running short time, stocks of castings are dwindling to the point of exhaustion, and steel producers are hampered for want of moulds. If the situation does not quickly improve, it is probable that advantage will be taken of the Christmas holidays to set down for a considerable period. In contrast, business in railway, tramway and automobile steel is more active than at any period since the armistice. Foreign buyers are coming forward freely, and altogether requirements of manufactured steel are on a wide and promising basis. Makers of railway axles, springs and tyres are able to show much more satisfactory order books, not only on home account, but also largely as a result of increased Colonial purchases. At the rolling mills, conditions are becoming congested, and employers are revising working arrangements so as to expedite output. Though Sheffield plays a moderate part in the manufacture and supply of motor vehicles complete, by far the greater tonnage of motor steel produced is for automobile makers in other parts of the country and in France. These are working under great pressure to wipe off heavy arrears, and are pressing local steel rollers for increased deliveries of semi-manufactured material. Business in engineers' tools is rather slack, but this is largely counterbalanced by the brisk demand for files and saws. Wage advances have brought about a further increase in quotations for steel billets, ranging from 10*s.* to 20*s.* per ton. Siemens acid are now offered at 20*l.* 2*s.* 6*d.*, Bessemer acid at 19*l.* 2*s.* 6*d.*, hard basic 17*l.*, and soft basic 16*l.* 10*s.*

South Yorkshire Coal Trade.—Collieries have placed substantial orders with wagon builders for rolling-stock, and if deliveries are kept within the provisions of contract specifications, considerable relief should be brought to the coal trade within the next two or three months. At the moment, operations are restricted more on account of the wagon shortage than owing to deficient output. The strength of the demand for steam fuels of all descriptions emphasises the renewed pressure of activity in the iron and steel trades. Shipments *via* the Humber are rather more robust, but the bulk of the output is reserved for home requirements, and in many cases is sufficient only to keep works running on day-to-day supplies. Similar conditions obtain in regard to house coal. The demand continues much in excess of the available tonnage. On the Coal Controller's instructions preferential treatment is being meted out to Metropolitan consumers. Local merchants are much in arrear with orders. Cobbles, nuts, slacks and coke are all firm at top rates. Quotations:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Some surprise has been created this week by the announcement of a 3*s.* 6*d.* advance in the price of No. 1 Cleveland pig-iron. That the rise was unexpected is borne out by the fact that shortly before makers decided to put the price up, at least one transaction was recorded at the old figure. Just at the moment, however, the change is not important as there is very little No. 1 iron available for sale. All foundry iron continues scarce, notwithstanding reduced local consumption. Demand from Scotland is as heavy as ever, and consumers there are taking a fair proportion of forge iron, which quality is quite abundant. Deliveries

of Cleveland pig-iron to customers North of the Tweed are limited only by the truck position. For home consumption, No. 1 Cleveland pig-iron is now 167*s.* 6*d.*, but No. 3 g.m.b., No. 4 foundry and No. 4 forge all remain at 160*s.* Export prices are 5*s.* above these rates.

Hematite Iron.—There is an easier feeling in East Coast hematite. Local steelworks would take more if the trucks were forthcoming to deliver, and much-needed iron is having to be put into stock. Demand from abroad is less keen. Supply continues very ample, but makers show no disposition to lower prices. No. 1 is 202*s.* 6*d.* for home purposes, and 207*s.* 6*d.* for shipment to foreign ports, and mixed Nos. are 200*s.* for home use and 205*s.* for export.

Foreign Ore.—There is not very much passing in foreign ore. Rumours of a cheap sale of best rubio lack confirmation, and the market rate of that article appears to be still in the neighbourhood of 52*s.* 6*d.* *c.i.f.* Tees, but both buyers and sellers are disinclined to operate, the former being fairly well placed, and the latter in arrears with deliveries.

Coke.—Local demand for coke keeps heavy, and supply is not over plentiful. Average blast-furnace quality commands 48*s.* at the ovens.

Manufactured Iron and Steel.—Producers of finished iron and steel have a vast amount of work on hand, and, in fact, some firms are so fully booked up that they cannot entertain further business, and have had to refuse quite a number of orders. Consumers from practically all quarters are clamouring for supplies. Values, all round, are very strong. Export quotations continue matter of individual negotiation, but may be given as a little above the following, which govern the home trade:—Common iron bars, 22*l.*; marked bars, 25*l.*; strip iron, 23*l.* 5*s.*; block sheets, 27*l.* to 28*l.*; galvanised sheets, 36*l.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel boiler plates, 21*l.* 10*s.*; steel angles, 17*l.* 15*s.*; steel joists, 17*l.* 10*s.*; and heavy steel rails, 16*l.* 10*s.*

Truck Shortage.—The very serious trouble through shortage of railway wagons is becoming alarming. It is causing dislocation of trade, and the very gravest view is taken of the manner in which output is being retarded. The steel works appear to be suffering most from inadequate supply of rolling stocks, but great inconvenience is also caused to pig-iron producers, and at the ironstone mines, and collieries. The actual closing of two of the larger steel mills in the district through the truck shortage is serious enough, but unless speedy relief is forthcoming by increased supply of rolling-stock, further stoppages are bound to occur, and the position will become even more grave.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The Scotch steel works are nearer full working order this week, but production is not yet up to the standard, and a little time must elapse before the pre-strike position is regained. Business is plentiful despite the latest advance in prices, and a very heavy demand for ship plates is current, with Clyde shipbuilders pressing for supplies. Deliveries are improving and every endeavour is being made to keep consumers going. Owing to further advances in workers' wages and raw material the associated steelmakers in Scotland have been forced to raise their prices. The new minimum rates came into force last Friday, and all deliveries on that day were affected. The current prices are as follow: Ship plates, ¾ in. and up, 19*l.* 15*s.* per ton; under ¼ in. down to and including $\frac{7}{16}$ in., 24*l.* per ton; $\frac{7}{16}$ in. down to and including ¼ in., 25*l.* 10*s.* per ton angles, 19*l.* 5*s.* per ton; and boiler plates, 24*l.* per ton, all net, delivered in the Clyde area, and for home consumption. There is more doing in sections at present, and deliveries are very satisfactory, while some good lots are being shipped abroad. The black sheet trade is still very active and makers cannot keep pace with the demand as the output from the mills is not nearly sufficient to cope with the present volume of business. This latter is really so large and urgent that it is doubtful if the present position was ever approached before, and even with current prices so high it has been stated that to get a certain lot shipped quite a substantial increase on home prices has been offered and paid. Galvanised sheets are also very active at full prices. Export inquiries are very good, but on the whole there is very little steel material going foreign, owing to the urgency of the demand for home requirements.

Malleable Iron Trade.—The malleable iron makers in the West of Scotland are experiencing a strong flow of business at present and active conditions are general throughout the trade. Consumers keep pressing for deliveries, which are fairly satisfactory, but the man who is in desperation for material sometimes thinks otherwise, although makers are doing their best to keep everybody well supplied in turn. Prices are strong and show no change.

Scotch Pig-Iron Trade.—Practically no change falls to be reported in the Scotch pig-iron trade, and the business going through amounts to a very large tonnage. Nearly all kinds of iron are in demand, and makers are fairly well placed so as to give reasonably good delivery. Forge iron is rather quiet. Deliveries of hematite to the local steel works are on a large scale, and if normal production is maintained the needs of the steel makers will be assured for many months to come, even allowing for their excessively heavy demand at present. The export trade shows improvement.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Coal Market.—A change has taken place in the condition of the coal market during the past week. Shipping has arrived more freely and, though collieries are still experiencing difficulty in connection with transport facilities, prices have hardened to the extent of 2*s.* 6*d.* or more for both prompt and forward loading, and even for spot shipment it is difficult to obtain concessions. In fact, though some collieries have as many as a dozen boats in docks, they have had to effect temporary stoppages because of the shortage of empty wagons. Best Admiralty large coals, which were obtainable a week ago at anything from 70*s.*, now command 75*s.*, with seconds round 72*s.* 6*d.*, while Monmouthshire cannot be secured under 70*s.* Steam smalls are also scare, with the best descriptions worth from 55*s.* to 57*s.* 6*d.* and sellers indicating up to 60*s.* Seconds are round 52*s.* 6*d.*, ordinaries 45*s.* and inferiors from 35*s.* up. The announcement of Sir Auckland Geddes that the price of coal for inland consumption is to be reduced by 10*s.* per ton from Monday next came as a "bombshell" to the market. Though a reduction was expected it was not anticipated that it would run into more than a few shillings. It is also reported that the present system of licensing exports is shortly to be terminated, and it is expected that there will be an increase in export prices. The proposal of the Government to limit colliery profits to 1*s.* 2*d.* per ton has raised a storm of protest from traders and also from the colliery proprietors and exporters. Resolutions have been passed by the South Wales Coal Owners' Association and the Cardiff Chamber of Commerce protesting against the proposal of the Government. It is felt that the coal trade is being singled out for special and unfair treatment, and measures are being taken to oppose the Bill. Mr. T. J. Callagan, at a special meeting of the Chamber of Commerce, described the proposal as "robbery."

The Iron and Steel Trades.—Inadequate transport facilities are seriously interfering with the tin-plate trade, and it is reported that unless something is quickly done to improve the position there is a possibility of works being forced to close down. Prices generally are firm, with little business passing, because manufacturers in the majority of cases are already full up with orders which will take them well into next year. For the basis box 46*s.* to 47*s.* is quoted for delivery in the first quarter of 1920, and inquiries are numerous. Pacific Coast salmon packers are expected to come on the market for 100,000 boxes of odds for January-March shipment, to pack the wet catch of fish, owing to labour troubles in the United States. There is, however, a possibility of increased outputs, as the water supply is now more plentiful. The price of galvanised sheets has increased 10*s.* per ton, and for 24-gauge stand at 38*l.* to 38*l.* 10*s.* for January shipment. Some works are fully booked up and asking 39*l.* for 6-gauge corrugated in bundles.

AMERICAN LOCOMOTIVES FOR EGYPT.—According to *The Iron Trade Review*, Cleveland, Ohio, an award of 50 locomotives for Egypt has been made to the Baldwin Locomotive Works. Inquiries for 65 additional locomotives for Egypt are current.

PETROL CONTROL DEPARTMENT.—This department, 20, Berkeley-street, W. 1, was closed on the 22nd inst. All further communications in connection with the matter hitherto dealt with by that department should now be addressed to Mr. P. G. L. Webb, C.B., C.B.E., at the Patent Office, 25, Southampton Buildings, Chancery Lane, W.C. 2.

INDUSTRIAL LEAGUE AND COUNCIL.—A lecture arranged by the Industrial League and Council (incorporating the Industrial League and Industrial Reconstruction Council), will be held in the Council Chamber of the Guildhall, on Tuesday, December 2. The chair will be taken at 2.30 p.m. by Sir Richard Vassar-Smith, Bart., and an address on "Government Control and Industry" will be delivered by the Right Hon. Lord Emmott, G.C.M.G., G.B.E. Admission is free.

ALUMINIUM ALLOYS.—The United States Bureau of Standards has recently issued two papers on aluminium alloys. In Technologic Paper No. 132, P. D. Mevica, R. G. Waltenberg and A. N. Finn deal with the properties of ternary alloys of aluminium and magnesium with copper, manganese or nickel. The alloys were rolled out in sheet and tested as cold-rolled, after annealing, and also after quenching at 500 deg. C. and aging at ordinary temperature. In the tensile tests the copper alloys came out decidedly best, and they were further improved by heat treatment, which improved the nickel alloys only a little and the manganese alloys not at all. For the corrosion tests the alloys were sprayed with salt water for two months. In these tests the Al-Mg alloys behaved better than aluminium itself and than other Al alloys, and the ternary manganese alloy proved least corrodible, the copper alloy coming next in order. Annealed commercial aluminium was more resistent to corrosion than the hard-rolled metal, but it did not compare favourably with most of the alloys. The "Heat Treatment of Duralumin" is the subject of Scientific Paper No. 347, by Mercia, Waltenberg and H. Scott. The temperature of quenching should not exceed the eutectic point of $CuAl_2$, about 520 deg. C., but should be kept near that temperature and be followed by quenching in boiling water and, for hardening the metal, by aging at 100 deg. for five days. The paper discusses the theory and mechanism of this hardening.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, November 28, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, London, S.W. A discussion on "Lubrication" will take place, in which the following gentlemen will take part: Dr. T. E. Stanton, F.R.S.; Principal S. Skinner, M.A.; Mr. W. B. Hardy, Secretary, R.S.; Mr. F. W. Lanchester, M.Inst.C.E.; Mr. H. M. Martin; Mr. R. Mountford Deeley; Mr. L. Archbutt, F.I.C.

THE ROYAL SOCIETY OF ARTS.—Monday, December 1, at 8 p.m., Cantor Lecture, "Synthetic Drugs," by Mr. John Theodore Hewitt, M.A., D.Sc., F.R.S., Emeritus Professor of Chemistry, East London College, University of London (Lecture I). Wednesday, December 3, at 4.30 p.m., Ordinary Meeting, "The Oil Seed Crushing Industry," by Mr. John Westall Pearson, Chairman and Director, British Oil and Cake Mills. The Right Hon. Lord Lamington, G.C.M.G., G.C.I.E., will preside.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 2, at 5.30 p.m. Paper to be further discussed: "Admiralty Harbour, Dover," by Mr. Maurice Fitzgerald Wilson, M.Inst.C.E. And ballot for new members.

THE JUNIOR INSTITUTION OF ENGINEERS, MIDLAND SECTION.—Tuesday, December 2, at 8 p.m., in the University, Edmund-street, Birmingham, the president-elect, Professor F. W. Burstall, will deliver his Inaugural Address, the subject being "The Professional Status of the Engineer." Meeting to commence at 8 p.m.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, December 3, at 8 p.m., in the Hall of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W. 1, when Mr. Edgar N. Duffield will read a paper entitled "Car Design and Car Usage from the Point of View of the Majority of Owner Drivers."

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, December 3, at 8 p.m., at the Royal Institution, Colquitt-street, when a paper will be read by Mr. John Watson, M.I.N.A., M.I.Mar.E., entitled "Marine Propelling Shafting, Bearings and Supports."

THE INSTITUTION OF LOCOMOTIVE ENGINEERS, MANCHESTER CENTRE.—Friday, December 5, at 7 p.m., at the College of Technology, Manchester. (1) Nomination of Candidates for election as chairman, vice-chairman, secretary and members of committee. (2) A discussion will take place on a paper by Mr. G. H. Jackson, member of committee, on the "Testing and Examination of Material for Rolling-Stock Construction." As the paper will not be read any member desiring to take part in the discussion is requested to apply to the secretary for an advance copy of the paper.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, December 5, at 7.30 p.m., at 39, Victoria-street, S.W. 1. "Some Notes on Extra High-Tension Switch Gear," by Mr. E. F. Hetherington, Member.

THE INSTITUTION OF WATER ENGINEERS (INCORPORATED 1911).—Friday, December 5, at 2.15 p.m., at the Apartments of the Geological Society, Burlington House, W. The chair will be taken by the president, Mr. Alfred B. E. Blackburn, B.Sc., Assoc.M.Inst.C.E., F.G.S. The following papers will be read and discussed: (1) "The Madras City Waterworks" (Part I, Historical and Descriptive), by Mr. James Welby Madeley, M.A., M.Inst.C.E., Special Engineer; (2) "The Repair of a Service Reservoir damaged by Mining," by Mr. Duncan M. Straughen, of Sunderland; (3) "Flow in Channels where the Water Surface is not parallel to the Invert," by Professor Alex. H. Jameson, M.Inst.C.E., M.Sc., of King's College, London.

THE TECHNICAL INSPECTION ASSOCIATION.—Friday, December 5, at 7.30 p.m., at the Rooms of the Society of Arts, John-street, Adelphi, when a joint paper on "Inspection and Testing of Materials" will be read by Messrs. R. D. Summerfield and H. J. Davey, Members. Discussion will follow the reading.

IRON AND STEEL INSTITUTE.—Dr. J. E. Stead, F.R.S., F.I.C., has been nominated by the Council of the Iron and Steel Institute as president for next year, in succession to Mr. Eugene Schneider. Dr. Stead has been a member of the council since 1895. He was elected vice-president in 1910, and for some time has been the senior vice-president of the Institute. We feel confident that all the members will receive this news with the greatest pleasure. The next annual meeting of the Institute is to take place in London on Thursday and Friday, May 6 and 7, 1920. The date and place of the next autumn meeting will be announced later.

PERSONAL.—Mr. D. M. Watson, B.Sc., Assoc.M.Inst.C.E., has entered into partnership with Messrs. Dodd and Dodd, M.M.Inst.C.E., civil and consulting engineers, County Chambers, Corporation-street, Birmingham. Mr. Watson has both American and English experience of professional work, while Messrs. Dodd and Dodd have had some thirty-five years of wide and varied experience in the design and construction of civil engineering work both in England and abroad. The name of the new firm is Dodd, Dodd and Watson.—The Renew Electric Lamp Company has been taken over by the Aladdin Renew Electric Lamp Corporation, Limited, 843 to 847, Harrow-road, Willesden Junction, N.W. 10, which has a nominal capital of 200,000*l.* The London depot has been considerably enlarged, and factories and branches are being set up in all the principal centres.

CONTROL GEAR OF 12-IN. GUN MOUNTINGS FOR H.M.S. "AGINCOURT."

CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, ELSWICK, NEWCASTLE-ON-TYNE.

(*For Description, see Page* 703.)

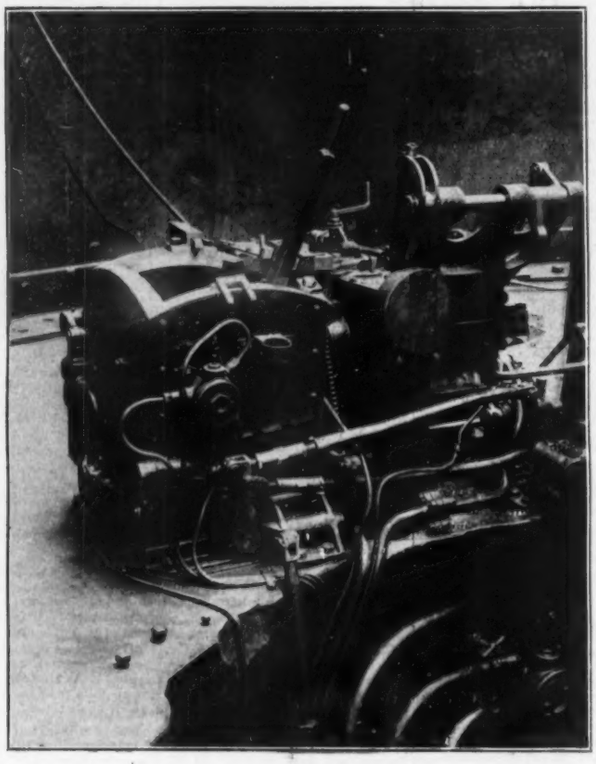


FIG. 9. LEVER IN POSITION FOR OPENING GUN BREECH MECHANISM.

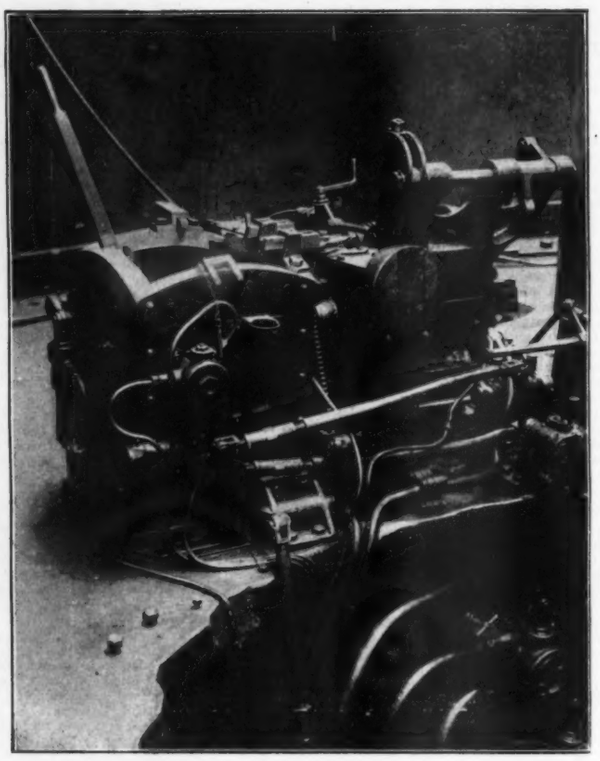


FIG. 11. LEVER ACTUATING CAGE FOR RAISING GUN CHARGE.

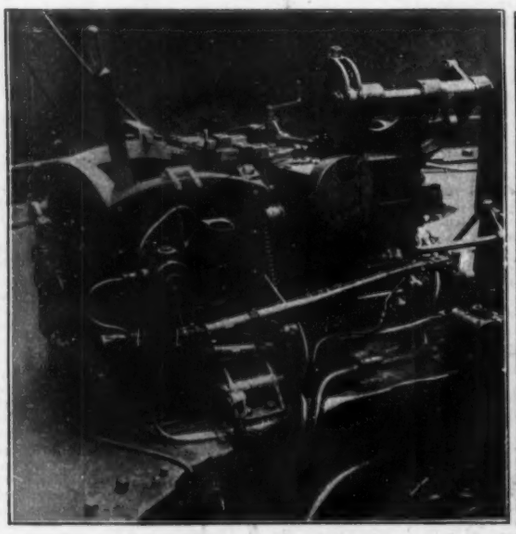


FIG. 10. LEVER IN POSITION FOR PLACING GUN AT LOADING ANGLE.

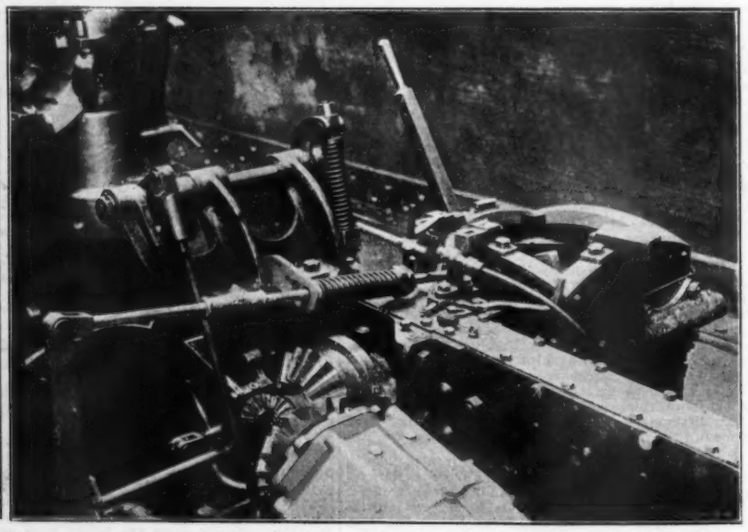


FIG. 12. LEVER IN POSITION FOR ACTUATING RAMMER.

TRADE OF THE UNITED STATES.—We read in *Commercial America* that for the year ending June 30, 1919, the total value of the United States exports were 7,225,084,257 dols. (as against 2,364,579,148 dols. for the year ending June 30, 1914); whilst the total value of the imports into the United States for the year ending June 30, 1919, was 3,095,876,582 dols. (as against 1,893,925,057 dols. for the year ending June 30, 1914).

BRITISH CATALOGUES FOR LIÈGE.—The Federation of British Industries have been in communication with the British Vice-Consul at Liège (Belgium) with regard to the display of catalogues and publicity matter at the Vice-Consulate, and from the list received giving the branches of industry in which his collection of catalogues is especially weak, the following articles interest our readers: Non-ferrous metals; cast-iron pipes and tubes; jointless pipes and tubes; pumps, ventilators and cables for coal mines; motor cars—light, well made, for two or three persons, capable of being sold at 12,000 francs to 18,000 francs; cycle cars, motor cycles and side cars; accessories; bicycles and accessories; chemicals for industries and chemists; leather, for manufacturers of belting and footwear; dyes, especially aniline colours; paints and varnishes; optical supplies—lenses, spectacles, glass; glass for industrial purposes—gauge glasses, &c. Certain types of goods do not lend themselves easily to representation by catalogues. In such cases, where the articles are not of a bulky nature, the Vice-Consul states that he is willing to receive samples for exhibition, and that arrangements have been made for the provision of sufficient space at the Vice-Consulate for this purpose.

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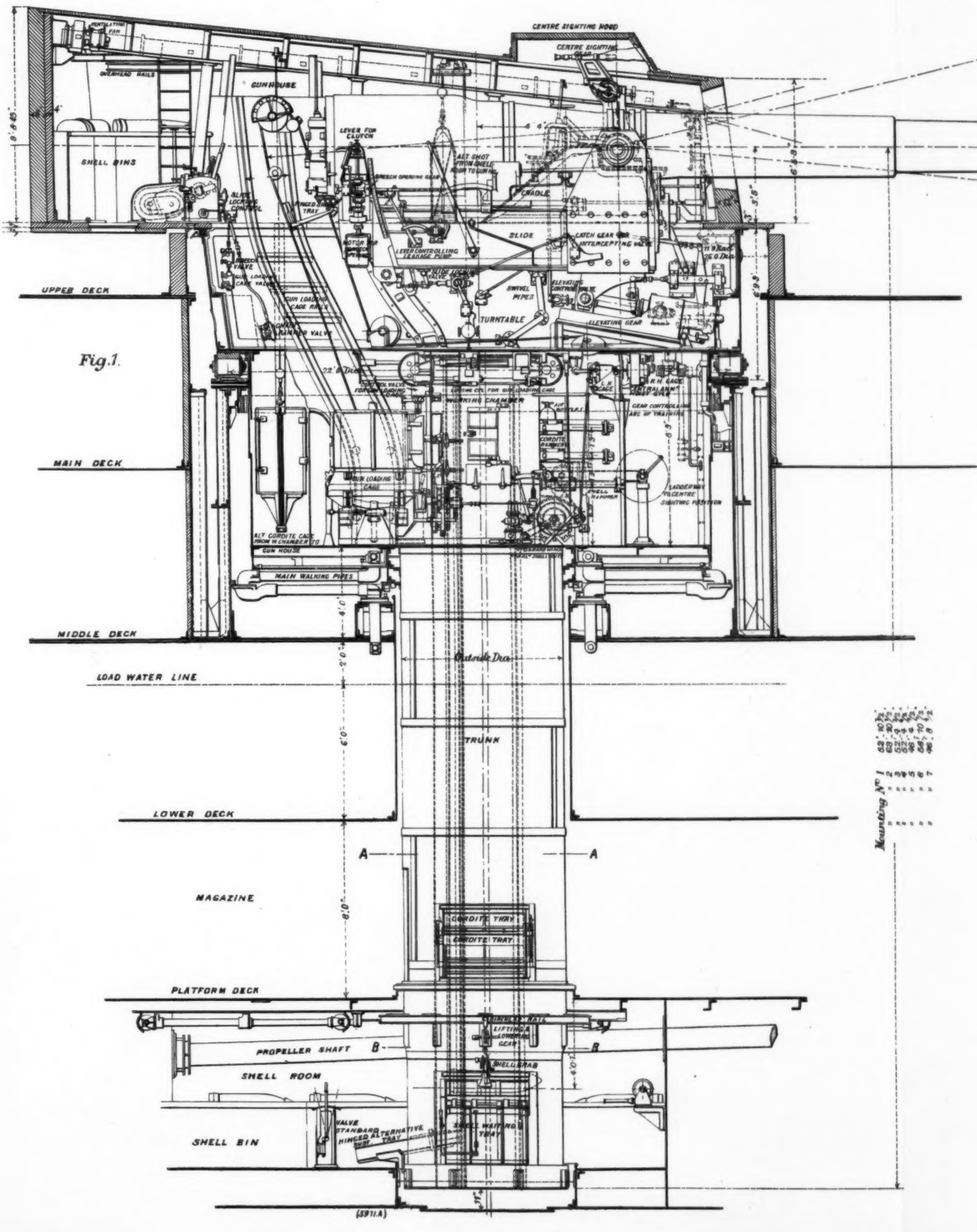

Fig.1.

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CONSTRUCTED BY SIR W. G. ARMSTRONG, WHITWORTH AND

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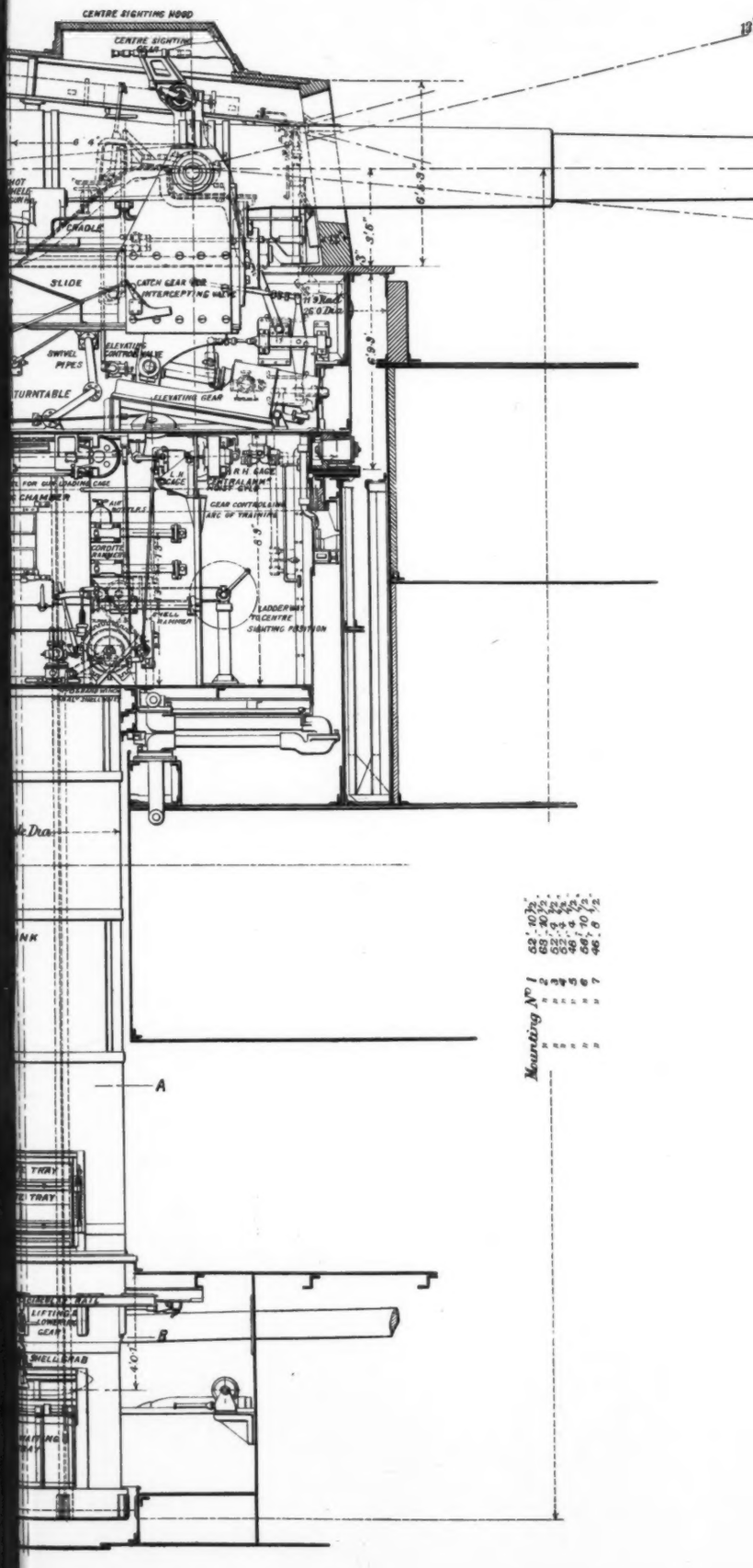

S MAJESTY'S BATTLESHIP "AGINCOURT."

RTH AND CO., LIMITED, ELSWICK, NEWCASTLE-ON-TYNE.

ion, see Page 703.)

13° Elevation

5° Depression

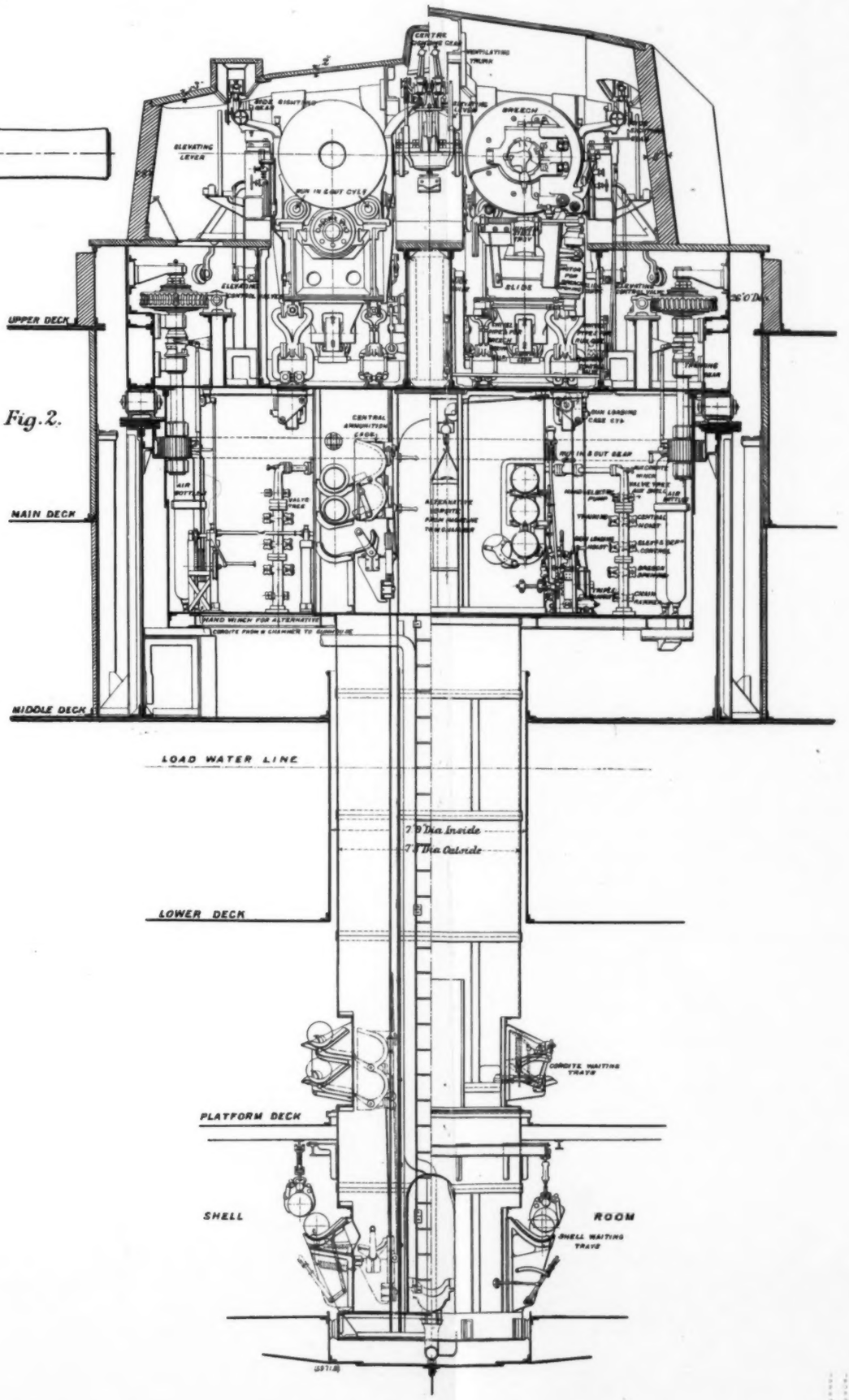

Fig. 2.

AGENTS FOR "ENGINEERING."

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TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue.
For Advertisements, J. S Allan, 18, Broadway, New York.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

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Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

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TELEPHONE NUMBERS—3883 and 8596 GERRARD.

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NOTICE.

Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase will date from and include the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 719.

ENGINEERING.

FRIDAY, NOVEMBER 28, 1919.

THE GOVERNMENT'S IMPORTS AND EXPORTS REGULATION BILL.

THE Bill introduced into the House of Commons by the Government for the regulation of imports and exports is one of the most important measures brought forward in this busiest of Parliamentary sessions. It is an attempt to meet the difficulties which proved of such grave consequence in the early years of the war, when it was established that some of the industries vital to the supply of munitions of war had been impaired by "dumping" on the part of competing nations in Europe, and by the complacence of some of our industrialists who were too short-sighted to realise that by purchasing in the cheapest market they were making themselves dependent on other nations, who were ready to take advantage of our weakness when occasion arose. One significant instance was that brought out by the committee presided over by Lord Balfour of Burleigh, a noted Free Trade Unionist. Proof was adduced by that committee that the dumping of German forgings had prevented some of our gun-makers from continuing to modernise their presses in order to enable a sufficiency of big guns to be constructed. Similarly, owing to the absence of the somewhat inappropriately called "key" industries some munitions could not be produced. For instance, because we had bought all magnetos from Germany, we were unable to complete aircraft and other petrol engines for a long time after the outbreak of the war until the magneto factories had been organised. The Bill now introduced attempts to rectify such serious defects in our industrial organisation. Another trade problem has arisen quite lately, owing to the great difference in foreign exchanges, and the Government have tried to find a solution for the excessive importation of goods due to cases of the rate of exchange being against us.

The Bill is in no sense a Tariff Reform measure. Judged on this standard, it would be utterly rejected by those who have advocated changes in our fiscal system. On the other hand it will, if honestly applied, put an end to that measure of Free Trade which has been a drawback to some branches of our manufactures. The war has brought enlightenment on the economics of international trade, and has established the view that employment cannot be maintained for all if we refuse to do to others as they do to us, or if we permit them to do to us that which they object to us doing to them. Instead of imposing tariffs, the Bill provides for the prohibition of imports of goods which come within a certain definition of "dumped goods," and others affecting key industries, but some of these can be introduced by licence granted by the Board of Trade, on payment to the Board, and thence to the Treasury, of sums of money equal to the difference in the foreign value and the "import price" or the "price of first sale," to which terms we shall refer later. Similarly, in the case of imports influenced by adverse rates of exchange, a corresponding sum has to be paid according to the difference between the sterling value of the imported goods and the price at which similar goods manufactured in the United Kingdom can be sold. The principles of the Bill may be accepted generally, but the machinery for carrying them into effect requires to be simplified. Moreover, the carrying into effect of the measure must, in many instances, be made obligatory rather than optional on the part of the Board of Trade.

The whole scheme is to be administered by the Board of Trade, who are to appoint a "trade regulation committee," which will include the President of the Board of Trade, the Financial Secretary to the Treasurer, the Parliamentary Under-Secretary of State for Foreign Affairs, the Secretary of the Department of Oversea Trade, two permanent secretaries of the Board of Trade, the Controller of the Department of Overseas Trade, and ten members of the House of Commons, nominated by the House, with a chairman to be appointed by the President of the Board of Trade. Objection is sure to be taken even in the second reading debate next week, to the composition of the committee, as it is regarded as too bureaucratic. There is need for manufacturers to be more directly and fully represented, and it may be preferable to give it also a more judicial constitution. The committee will only exist, too, for the consideration of the Orders to be drafted by the Board of Trade, and even then in cases of emergency such orders can be put into effect for a period of 21 days, pending their approval by the committee. The committee, it would appear, is to have no powers for originating any proposals, but probably this may be conceded in practice.

As regards dumping, importation may be prohibited altogether at the discretion of the Board of Trade, in the case of goods of any class or description produced and manufactured abroad, and "systematically and in substantial quantities imported into the United Kingdom at prices below the foreign value or where such importation is apprehended, and where the production and manufacture of similar goods here is, or is likely to be, thereby adversely affected." Provision is made for a sworn declaration of the foreign value of the goods, and enquiry may be held for the ascertainment of their foreign value. In the event of goods being imported, and it being found afterwards that such importations are illegal, the importer, before clearance of the goods, must pay a sum equal to the amount by which the foreign value of the goods exceed the import price. An important question has reference to the interpretation of the phrases "foreign value," "import price" or "price of first sale," and there is certain to be a sharp conflict of opinion on these points, not so much as regards large engineering productions as in goods of relatively small value and imported in large quantities, since the market conditions, which vary greatly, are largely operative in determining the values and prices. The Bill as at present drafted states that the "foreign value" means the price calculated in sterling which "was being charged for goods of that class or description in similar quantities for consumption in the country of production or manufacture, after deducting any excise or other internal duty leviable in that country, or, if no such goods are sold for consumption in that country, the price which, having regard to the prices charged for goods as near as may be similar when so sold or when sold for exportation to other countries, would be so charged, after deducting any such duty as aforesaid if the goods were sold in that country." Difficulties are sure to arise in the interpretation of this definition, which is not sufficiently precise. Is the value the works value or the wholesale price?

The section of the Bill dealing with key industries provides for the prohibition of the importation of certain goods which are specified, and for the prohibition, of other goods enumerated, for the period of three years from the termination of the present war. The former are associated with dyes, chemical industry, optical glass, scientific and illuminating glassware, laboratory porcelain, scientific instruments, tungsten powder and ferro-tungsten, zinc oxide, lithopone, arc lamp carbons and carbon

electrodes, magnets and permanent steel magnets, gauges, &c. But it is not quite clear that in all cases complete goods which largely embody the enumerated items on the list are included. For instance, very cheap cameras may be freely imported carrying valuable lenses suitable for other purposes and the same might apply to complete chemical products, the main part of which is made up of constituents the importation of which is prohibited. Moreover, the list could very properly be extended.

As regards the effects on imports due to depreciation of foreign currency, it is provided that the Board of Trade may prohibit importation on being satisfied that there is such a depreciation in the sterling value of the currency of any foreign country as would cause sales of manufactures in the United Kingdom to take place in "substantial" quantities at prices "substantially" below those at which similar articles manufactured in the United Kingdom can be sold. The Board, however, have power to grant licenses to authorise importation of some goods which come within the definition of "key" industries, or of industries affected by the depreciation of foreign currency, after enquiry on the claim of any applicant. A fee is to be charged for such license either on the value or on the quantity of the goods, and is not at the time of its imposition to be greater than the difference between the sterling value of the imported goods and the price at which similar goods manufactured in the United Kingdom can be sold, if sold in similar quantities and for delivery at the manufactory. In the case of the importation of goods affected by the depreciation in foreign currency the license may be issued without payment or the payment of a sum at a uniform *ad valorem* rate determined from time to time and for periods of not less than three months. This seems too long a period especially under present conditions when the exchanges are fluctuating so much. "Sterling value" is defined as "the price in sterling which the importer would give for the article if the article were delivered freight and insurance paid, but excluding any license fee or rate leviable at the port of importation." In determining the issue of a license consideration will be given to any attempt at combination or restriction of the conditions affecting output in this country in order artificially to raise prices, and the Board of Trade are taking powers to investigate any attempt in this direction.

A further part of the scheme provides for the prohibition of exportation temporarily of certain goods, including fuel, motor spirit, certain food stuffs, opium and its preparations, cocaine and its salts; but here also a license may be granted in special cases. This prohibition will continue for three years after the termination of the war and no longer.

A provision in the Bill which will largely be commended is that which gives power to the Board of Trade to make arrangements for granting credits in connection with export trade, the maximum amount defined being 26,000,000*l.* sterling. The Board may also undertake the business of insurance or re-insurance of any goods where risks of an abnormal or exceptional nature are involved, and for that purpose may fix and receive premiums. This provision, however, is only to continue in operation for three years, although the period for repayment of grants will continue for six years.

THE ROADS AND TRANSPORT EXHIBITION.

The synchronisation of the Cycle Show, the recent meeting of the Institution of Mechanical Engineers, and the Roads and Transport Congress and Exhibition at the Agricultural Hall, results in a considerable part of our space this week being devoted to matters of road transport. In view, however, of the attention now being attracted to this subject and its intrinsic importance, the circumstance requires no apology. At recent functions, both of the Society of Motor Manufacturers or Traders and the Association of British Motor and Allied Manufacturers, a good deal was said of the part played by motor traction during the war and in connection with the recent railway strike. The work in both connections was beyond praise, and we would criticise neither. There is, however, an aspect of the work done during the strike which, in satisfaction at a menace successfully countered, has perhaps pardonably, been to a large extent ignored. This is the question of cost. The amazingly successful handling of food supplies by motor traction has in more than one quarter raised dreamings and imaginings of wonderful things on the roads. The motor vehicle has unquestionably been raised to a stage at which it can do those things, but whether it can do those things on an economic basis is another matter. This question was in effect the subject of Mr. Conradi's paper before the Institution of Mechanical Engineers, and was, we trust, largely kept in mind by visitors to the Roads and Transport Exhibition.

The Exhibition was held at the Royal Agricultural Hall during the latter part of last week and the early part of this. The Congress, which was held in connection with the Exhibition, we deal with elsewhere in this issue. Here we propose to say something of some features of the Exhibition. It contained much of technical interest, but from the point of view from which we are taking the liberty of regarding it, did not contain all we would have wished. We are abundantly aware that the Exhibition did not pretend specifically to illustrate the subject of the development and possibilities of economy and greater efficiency in road transport, but these matters are of such importance that we regret they were not more definitely accentuated. The paper read before the Institution of Mechanical Engineers is open to criticism on a parallel score. It was concerned with the necessity for adding efficiency to road transport by improving methods of loading and unloading, but confined itself to too great an extent to generalities. Generalities are useful and necessary, but with over-use they may become cheap. The improvement which is necessary can only be brought about by the work of engineers. What is wanted is sound mechanical design and the working-out of goods handling schemes in detail. The generalities are now well understood, and immediate further discussion of them may be left to the traffic manager and the newspaper expert.

With this introduction, we propose to call attention to various of the exhibits which were to be seen at the Agricultural Hall and to deal more especially with those which directly bore on the question of the cheapening, or, what is the same thing, the improvement of the efficiency of road transport. As a beginning we would say we were glad to see what was probably the best display of electric battery vehicles yet brought together in this country. It is established that for a certain type of short haul the electric battery vehicle can show superiority over both petrol and steam. This fact has but slowly been recognised in this country, but there are now signs that the electric vehicle is coming into its own. For many classes of municipal work, involving short journeys over good roads and somewhat frequent stops, the electric battery vehicle is peculiarly suitable, and there are signs that our municipalities are now recognising this. For much of this kind of work the battery vehicle can show lower operating costs and a smaller maintenance bill than its rivals, while in very many cases the fuel, or, rather, the energy, used is already a municipal product. A somewhat similar type of service is demanded by large retail stores, and such firms as Harrods and Lyons now use electric vehicles extensively.

Some of the firms which have in the past been associated with steam or petrol traction have now commenced the building of electric wagons or trucks, and examples were shown by Messrs. Richard Garrett and Sons, Ltd., of Leiston, and Messrs. Ransomes, Sims and Jefferies, Ltd., of Ipswich. Of firms whose name is more definitely associated with the electric vehicle, Messrs. Edison Accumulators, Ltd., of 3, Duke Street, St. James's, London, and Messrs. the General Vehicle Company, Ltd., of 43, Shoe Lane, London, had displays. The first three firms we have mentioned showed wagons with electrically operated tipping bodies, while the last had a patent electrically operated unloading gear. One of the obvious minor advantages of an electric battery vehicle is that power may easily be made available in any part of the chassis for auxiliary service, such as tipping. This advantage is, however, not of great moment in practice, since, as many of the exhibits showed, there is no difficulty in working out a purely mechanical power-operated tipping gear on a petrol or steam wagon.

Before saying anything in detail about the tipping arrangements on the electric vehicles, we have mentioned, we would like to refer to the question of tipping gears more broadly. The fitting of a tipping arrangement to a motor lorry is one of the obvious methods of reducing the unloading time for many types of traffic. It is, of course, a very old device, but does not appear to have been adopted by motor-wagon builders to any considerable extent until recently. The tipping of the body of a motor wagon may, of course, be attained in various ways, but the most common method appears to be the fitting of a tipping screw at the forward end. This screw is pivoted to the chassis and the body carries a nut working on the screw. As the screw is rotated, the nut rises and carries the body with it into the tipping position. Another device, shown in various forms, at the Agricultural Hall consists of a horizontal screw, carrying a sliding nut, to which is attached a link or toggle sliding on or pivoted to the wagon body. The travel of the nut backwards causes the tipping. This device is in a sense neater than the vertical screw, since when the body is home it is out of sight. The vertical screws, it should be mentioned, are very frequently made telescopic, a screw of small diameter resting inside a hollow one of larger diameter. This arrangement is used in order that when the body is down the vertical height to which the tipping screw stands shall not be too great.

Tipping devices, such as we have described, were in general operated by hand, but in some instances mechanical connection to the engine was made. Arrangements of this sort were, for instance, fitted by Messrs. Leyland Motors (1914), Limited, of Leyland, and Messrs. Walker Bros. (Wigan), Limited, of Pagefield Ironworks, Wigan. The disadvantage of hand operation would appear to be that in some cases extra labour would have to be carried by the wagon for the purpose of operating the tipping gear. It is likely that in many instances it would be held not to be driver's work. A mechanical gear operated from the engine should, however, come within the driver's province. The question of speed also arises. A hand gear would of necessity be somewhat slow, whereas mechanical tipping takes only a few seconds. We were particularly struck by the Walker Wagon in this connection, as it was shown in operation. The elimination of hand tipping was, in several cases, brought about by the fitting of hydraulic tipping rams, charged from a small pump, driven by the engine. Examples of this class of tipping were fitted to wagons shown by the Associated Equipment Company, Limited, of Walthamstow; the Daimler Company, Limited, of Coventry; Messrs. J. & E. Hall, Limited, of Dartford; the Albion Motor Car Company, Limited, of Glasgow; and Caledon Motors, Limited, of Glasgow. Most of these firms fitted one or two rams below the body, but Messrs. Hall had the ram arranged at the front of the body in a vertical position and carrying a pulley on the top, the body being actually lifted by a wire rope. The arrangement was the common one of hydraulic machinery.

A further point in connection with this matter which is worth notice is that of the power expended in tipping. This is clearly of more importance in the case of hand than of power tipping. Some of the wagon bodies were merely hinged at the back end and were lifted bodily. In others, more particularly some of those of the horizontal screw type, the body was first moved back horizontally on the level until the point of overbalance was reached, when the load tipped itself. This arrangement was shown by Messrs. Straker-Squire, Limited, of Edmonton. An ingenious device was fitted to the Edison electric battery wagon, which we have already mentioned. In this, the body was fitted with rollers which worked over a cam plate so arranged that the body, when tipping, rotated around its centre of gravity. This, naturally, reduced the power required for tipping. Another minor matter in connection with tipping wagons, is that

of the tipping angle. We did not collect full statistics but, in general, the angle arranged for appeared to be 40 deg. to 45 deg. The Pagefield wagon, of Messrs. Walker, which we have previously mentioned, however, raised the body to an angle of 60 deg. The minimum necessary angle will, of course, vary with the service, but it would appear that in dealing with some wet or sticky materials the large angle would be an advantage. It is clearly cutting down the efficiency of a tipping wagon, if it is necessary to carry a man with a shovel to get out the last 20 per cent. of the load.

Before concluding, there are one or two auxiliary appliances for use in connection with motor wagons, and of which examples were shown at the Exhibition, to which we would like to refer. One of these is trailers. Messrs. Tuke & Bell, Limited, of Lichfield, and Messrs. The Eagle Engineering Company, Limited, of Warwick, both showed side-tipping appliances of this class. Messrs. Tuke & Bell's appliance was ingeniously arranged so that it could tip from either side. The body was carried on rollers, and was pushed off from either side by nuts carried on lead screws. When the body reached the tipping position, hooks carried below it engaged with a horizontal rod, and the body rotated round it. The Eagle Company's wagon tipping only at one side, had a somewhat simpler construction. A gear to facilitate loading, as well as unloading, was shown in the form of the Stamper loading truck, which was exhibited on the stand of Messrs. H. G. Burford and Co., of Regent Street, London. This is an appliance which is described in Mr. Conradi's paper which we print this week, and consists of a truck with a movable body, which can be transferred fully loaded to the deck of a motor lorry. The General Vehicle Company's electric lorry was fitted with the Craymer unloader, which consists of a flooring built up of panels. The whole can be wound outward towards the rear of the wagon, and so carry the load to the taking-off position, or, if necessary, tip it. The various panels fold over as they reach the end of the wagon, and, finally, lie one below the other, so that they do not interfere with the unloading.

THE STUDY OF FLOTATION.

Ore concentration by flotation is driving the old-fashioned gravity concentration out of the field. Both are differential methods; both ultimately depend upon the effect of gravity upon ore and gangue particles, stirred into water or carried away by it. In the old process we rely directly upon the more rapid sinking of the heavier particles; in the flotation process we try to keep the valuable ore in the bank of froth collecting at the top of the agitated pulp. That we can do so is mainly ascribed to the buoyancy of air bubbles and to surface tension effects, differentiated by the action of oil and other agents. While scientists were hesitating to commit themselves to any definite explanation of flotation, practical flotation forged ahead*; the development of the past few years especially in America has been astounding. Some 400 flotation plants have been established there, and more than half a million tons of ores are now floated every year, though practical flotation has not come of age yet. If miners were first satisfied to separate sulphides from the gangue by flotation, they now separate sulphides from one another, and deal with oxidic ores, native metals and carbon, and in particular they work up many tailings and slimes that the metallurgists had to dump before. Such a development could not but react back on metallurgy. Big settling tanks, vacuum filters and conveyors are wanted for the frothy material, metallurgical furnaces have had to be adapted to finely-subdivided charges, the demand for Cottrell dust precipitators has received a powerful impetus, and hand labour is more and more being dispensed with. In fact, one may pardon advocates of flotation when they claim to have revolutionised metallurgy.

Practice has in this development outstripped theory. Scientists still shake their heads, and they have the excuse that the floaters have not entrusted them with their trade secrets. But a good deal has come out during the patent litigation of recent years, and the legal situation has cleared considerably, mainly in favour of Minerals Separation, Limited. Hence, Mr. H. Livingstone Sulman, one of the originators of the successful process of that company, felt at liberty to explain, on Thursday, November 20, his experience and his views in a "Contribution to the Study of Flotation," before the Institution of Mining and Metallurgy. He did not give technical details. He dealt with the physical problems, so simple, as he remarked, that he had wanted 96 pages to express his views. He might have shortened his paper by not attempting to give a summary of molecular physics. But he certainly presented a great array of data, partly new and based on observations of his own, bearing upon the very complex flotation phenomena in an instructive way. We should mention that he made frequent references to the valuable researches especially of Professor Edwin Edser and Mr. Emil Hatschek.

The simple experiments with which Mr. Sulman introduced his discourse well characterise the problems. He had a glass flask half full of water. When shaken the water became charged with air bubbles which quickly collapsed again. When a few drops of cresol—oxytoluense, corresponding to phenol, a somewhat oily liquid very sparsely soluble in water—were added to the water, the shaken liquid remained milky for some time. Ground sulphide ore was now put into the water, and the shaking repeated; the whole ore collected in a frothy mass on the surface of the water. Finally a few drops of sulphuric acid were added to the water; renewed shaking left a dark flocculent frothy mass of dark sulphide on the top, the liquid underneath was turbid with particles of the quartz gangue, and a whitish sediment of gangue settled at the bottom. The floating itself is largely due to the air bubbles and agitation; but a differential floating of the watery ore pulp had apparently been effected by the use of several agents: (*a*) A froth-producing material (cresol, amyl alcohol, &c.) which is to reduce the surface tension of the solid in order to make the air bubbles adhere to the mineral; (*b*) a stabilising agent, usually a minute amount of insoluble oil, to stiffen the froth; (*c*) a gangue-modifying agent (a mineral acid, alkali, salt—not of the heavy metals) increasing the adhesion between the gangue and water, that is, favouring the wetting and sinking of these particles. Both (*a*) and (*b*) are in our example and in general furnished by the same oily agent. Under suitable conditions any small particles will float, ores and gold as well as carbon and sulphur, calcite and quartz; thus the effects can hardly be chemical. The differential effect is clearly connected with wetting and surface tension; the question is how?

Liquid surfaces behave as if they were stretched membranes tending to contract. To extend a soap film requires a certain amount of work; the work done when the surface is increased by unity, expressed in ergs per square centimetre, is numerically equal to the surface tension, expressed in dynes per centimetre. The surface tension does not alone make up the whole surface energy; the stretching itself would cool the film, and heat must be taken up to compensate for the heat lost. The sum of this heat and of the surface tension work constitutes the surface energy, but the heat term is often disregarded in speaking of the phenomena. The theory has occupied great men like Laplace, Gauss, Kelvin, Van der Waals. We may imagine the molecules of liquids and solids to be held together by forces acting like springs; work must be done both to force the molecules apart and to compress them; that accounts for cohesion and its converse, the intrinsic pressure, and for the connection of surface tension with dilatation, compression and with vapour pressure. The ranges of these intermolecular forces must be very small; the estimates range from 5 $\mu\mu$ to 118 $\mu\mu$, however. In the interior of a liquid the molecules are equally attracted in all directions by their neighbours; at the surface they are more pulled inward than outward, and those molecules which have come to the surface have been driven there by some agency (*e.g.*, agitation, heat) and are endowed with more free energy than those in the interior; if with sufficient energy they escape and evaporate. Of liquids water has the highest surface tension, 75 dynes per centimetre (which may slightly be increased by the addition of sulphuric acid, however); other values are: Glycerin 65, cresol 34·8, petroleum 27·7, alcohol 21·6 dynes. But the surface tension of the liquid metal mercury is certainly much higher, about 440 (estimates differ widely). Mr. Sulman credits some fused metals with very high surface tension: Copper 1,178, gold 1,018, zinc 707, aluminium 520, lead 424, &c.; he did not state his authority; the most recent researches by F. M. Jaeger (Groningen),* made at temperatures up to 1,600 deg. C., did not concern metals so far as we are aware.

Since now the surface tension increases as the temperature is lowered, the question is: What becomes of this probably large amount of surface energy when the liquid metal solidifies? The energy cannot vanish; but we do not know how it is disposed of, nor do we know how to measure the surface energy of solids; that is the trouble. Estimates of the surface energy of sulphates, based upon the heat of solution, made by Hulett and others, remain unsupported and do not agree with some flotation experiments. Solid surface certainly seem to have a loose texture. By simple rubbing with the finger Beilby made metals and minerals "flow"; gases and liquids condense on solid surfaces; rust penetrates into hard quartz and porcelain; gelatine dried on glass tears the glass in peeling (Rayleigh); W. B. Hardy has quite recently† rubbed water into glass and has found that two such glass surfaces when once pressed together cannot be parted again without injuring the glass. He also states that oil spreads on glass first in an infinitesimal film and attributes the phenomena to vapour pressure rather than to surface tension. These two forces are interrelated, however, and Mr. Sulman treats all his problems from the standpoint of surface energy and interfacial tension.

When two surfaces, gaseous, liquid and solid, are brought into contact, Mr. Sulman argues, they may or may not adhere and spread upon one another. If substance A pulls its own molecules with a larger force σ, than it pulls the molecules of substance A_1, then the molecules in the surface of A will possess more energy than the molecules in the interior of A. If similarly the molecules of A_1 have more attraction σ_1 for their own molecules, the surface layer of A_1 will be energised. The excess energy of the joint layer at the interface of A and A_1 will produce an interfacial tension which, among other effects, will resist lateral extension. When a bubble of air adheres to

Fig. 1.

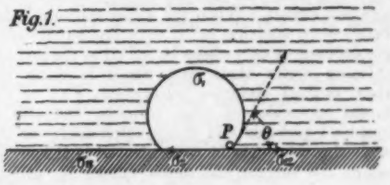


Fig. 2.

a solid surface (of surface tension σ_2) in a liquid of surface tension σ_1, the forces at the point P (Fig. 1) will be: σ_2; the component of σ_1, resolved parallel to the solid surface, *i.e.*, $\sigma_1 \cos \theta$, where θ is the contact angle; and the interfacial tension σ_{12}, such that $\sigma_2 = \sigma_1 \cos \theta + \sigma_{12}$, or $\cos \theta = \frac{\sigma_2 - \sigma_{12}}{\sigma_1}$. This angle of contact may vary between 180 deg., when the bubble would just touch at one point, and 0 deg., the case of maximum adhesion and (subject to qualifications) of complete wetting of the solid surface. The former case is approached by mercury since the contact angle between mercury and glass in air is 148 deg.; that would be an example of

* We dealt with some technical and historical features of ore flotations in our issues of August 28, 1916, page 169, and of November 24, 1916, page 514.

* See Engineering, July 24, 1918, page 584, and also Mr. Cosmo Johns on Steel, May 30, 1919, page 721.

† *Philosophical Magazine*, July 1919, pages 32 and 49.

non-wetting and least adhesion. When a drop of oil E of surface tension σ_2 (Fig. 2) is poured on water (σ_1), the drop will be pulled out into lens shape until equilibrium is established between the tension in the Neumann triangle of forces at P, such that $\sigma_1 = \sigma_2 + \sigma_{12}$; if σ_1 be larger than the sum of the other two forces, no triangle is possible, and P and Q will be dragged apart by the greater tension σ_1; the result would be that the drop rapidly spreads. We should ourselves rather say that the point P (and similarly Q) is squeezed out—not pulled out—by the inward pull of the forces in E, and we confess that we cannot follow Mr. Sulman in his deductions which aim at explaining all the complex effects observed by interfacial tension and the contact angle formula. But it would be unfair to criticise Mr. Sulman without reproducing his deductions at considerable length. Moreover, Mr. Sulman acknowledges that there is no quantitative basis for his applications of the formula, for which he does not claim originality, of course. It is not known which of two solids has the greater surface energy; yet we can alter the θ *e.g.*, by oiling. Like water, oil wets all dry substances, but makes smaller θ than water with sulphides and many other substances.

Various factors modify the surface energy, and the contact angle itself is not a constant quantity. When the plate on which a drop of oil rests is inclined, the drop will bulge out at the lower end, and will make a more obtuse θ there. When a plate is suspended vertically in a liquid which wets it, the liquid will be drawn up on both sides making acute angles of contact; when we tilt the plate to the right, the θ on the left side becomes larger, and that on the right smaller; when the plate is then left to itself, it will be pulled back into the vertical position. Thus there are maximum and minimum values of θ, and this "hysteresis" range of θ, Mr. Sulman finds, may amount to 60 deg., and is important because it enlarges the otherwise small range of θ which admits of floating. To what the hysteresis is due, is not understood; according to Edser, air is not condensed on solids to any appreciable extent, and the assumed gas films on solid surfaces would thus hardly have anything to do with the spreading of liquids and flotation, Mr. Sulman stated; this statement seems to need further support. Yet Mr. Sulman referred to the fact that fresh surfaces and cleavage faces behave differently from surfaces that have been exposed to the air; that is to account for the different results of flotation experiments made in the laboratory with old dry-crushed particles and in the works with wet-crushed fresh pulp. He also pointed out that adsorption in another sense modifies the surface energy to an important extent. When the water contains other substances in solution or in very fine subdivision, these substances may either be pulled to the surface, displacing water there and hence lowering the surface tension (positive adsorption, *e.g.*, of the complex molecules of soap, colloids, and also of minute oil globules and slimy sulphides); or the dissolved matter may be concentrated in the water, cleaning the surface and hence raising its surface tension, though not to any considerable degree (negative adsorption of sulphuric acid). Soap solution will reduce the surface tension of water from 75 to 28, whilst sulphuric acid will only raise it to 76·5 dynes. Similar considerations decide whether or not air bubbles and oil globules coalesce, and whether the particles will flocculate or deflocculate. Oils like petroleum, which are insoluble and useless as frothing agents, help to stiffen the froth. The more strongly adsorbed liquid or solvent displaces the other. Most of the vegetable oils used, pine oil, eucalyptus oil, &c., are chemically very complex and contain soluble constituents; their value is best found by trial in every particular case.

The old well-known flotation of a steel needle on water, a simpler and in some features dissimilar, not differential problem, has recently been studied by Edser and by W. H. Coghill and C. O. Anderson ("Journal of Physical Chemistry," 1918, 22, pages 237 to 253). The needle sinks below the water level and rests at the bottom of a sack of air which has the shape of an elongated drop of water about to fall from a surface. The buoyancy depends largely upon the depth of this sack; the water will partly be in direct contact with the needle, and only that portion of the needle below the line of contact will actually displace water. A whole cube may in this way float, and be practically submerged, the air adhering merely to the top face of the cube.

This system of "film flotation" of heavy particles has lost its technical importance. De Bavey made the ore pulp enter the water quietly at an incline; McKuisten and Sulman and Picard made use of slowly-rotating tubes at the one end of which the pulp entered, for floating the films. Actual ore flotation is selective or differential, and since 1905 Sulman and Picard have insisted upon the necessity of using a very minute oil film. Originally the oil allowance was largely limited by economy. Sulman recommends 2 lb. of oil per ton of ore, which is about 0·1 per cent. The pulp will still float with 0·5 per cent. of oil, he said; more oil is injurious* and, indeed, favours granulation and sinking of the particles (Cattermole). Oxidic ores can superficially be sulphidised by chemical means; but this is not done to any large extent, and direct flotation is often possible and probably more customary.

We have not referred to several of Mr. Sulman's points. The ore ought to be finely crushed in the wet, but there is no "critical grain" size. Electricity plays a part in the coagulation and flocculation of colloids and of ores; technical application of electricity with that object is probably not promising, but we do not understand that part of Mr. Sulman's paper. In his summary he accentuates that all the effects must not be regarded as merely static; they are dynamic and kinetic. The contact angle should be 90 deg. or exceed that amount. With plain water and crushed ore the various superficial effects overlap. The addition of oil or other agents to the pulp reduces the surface energy of the sulphide more than that of the gangue, and the submergence of the latter is further facilitated by the addition of acid. Frothing agents produce a froth with water, yet leave a partial strain at the bubble surface; the mineral adsorption stabilises the film, especially if the mineral be minutely oil-filmed. Acids, alkalis, silicate of soda, &c., remove the strain from the surface of the suspended gangue particles and promote their deflocculation.

It remains to be seen whether these various statements, not all concordant apparently, can be worked into a consistent theory of flotation. The speakers at the meeting hardly went beyond eulogistic remarks. But the discussion was adjourned, and we may refer to the matter again.

* This is the much-contested point: see our Note on "Ore Flotation," ENGINEERING, May 31, 1918, page 615.

THE MOTOR CYCLE SHOW AT OLYMPIA.

THE crowded alleys in the great hall at Olympia are sufficient evidence of the interest taken by the general public in what is officially termed the Fifth International Cycle, Motor-cycle, Cycle-car and Accessories Exhibition, which opened on Monday last. The previous exhibition of the kind was held in 1913, and the intervening years have seen the motor cycle put to a test which firmly established its right to be treated seriously as an important means of locomotion. We may say at once that the motor cycle dominates the exhibition. Ordinary pedal cycles are there, of course, in abundance, but their design has settled down for so long on absolutely standard lines, that without the motor cycle the exhibition would have lost all justification for its existence. The latter vehicle, so far, shows very little signs of standardisation of type. One would have thought that, even apart from the lessons of war experience, twenty years or so of commercial use would have indicated the general lines of construction which were most satisfactory, yet the divergence of ideas among designers appears to be at least as great as ever it was. Single-cylinder engines, vertical or inclined, twin V engines, twin opposed engines and even four-cylinder engines almost on motor car lines, all have their advocates. The four-cycle and two-cycle types seem each to hold its own, while as regards frame design hardly any possible combination of tubes seems to have been overlooked.

If one had the time it would be very interesting to make a proper statistical analysis of the machines at Olympia with a view to determining the trend of design. But failing any such definite test, a few general impressions may be recorded. In the first place, the two-cylinder horizontal "opposed" engine, known to motor cyclists as the "flat twin," appears to be distinctly gaining in favour. This was, we believe, first introduced by the Douglas Company many years ago, and has always been typical of their practice. Now it is embodied also in the Brough, Humber, Rayleigh, Wooler and possibly others. The two-cycle engine, at any rate for the lower-powered machines, seems to be greatly increasing in favour. Messrs. Dunford and Elliott, Limited, of Birmingham, are using the two-cycle principle in a single-cylinder engine of 500 c.c. capacity, although in general the type is confined to the light weights. Outside flywheels appear to be maintaining their position. A two or three-speed gear chain driven from the engine and belt connected to the back wheel is common practice, but a chain drive throughout also has its exponents.

The engines themselves, though of widely varying type, arrangement and size, do not call for much criticism, as in general they are sound mechanical articles, each in its own way. Frame design, however, in many cases is very questionable. For sheer ugliness some of the machines could hardly be beaten, and when the ugliness is unnecessary and is associated with, even if it does not arise from, a disregard of engineering principles, it is the more to be condemned. In very many designs the crank-case of the engine forms, structurally, a part of the frame, although it would seem far sounder engineering to make the frame structurally complete in itself and attach the engine to it. Some makers do this, the "Triumph Junior" machine, for example, being an excellent example of design both in this and in other respects, and one of the most pleasing machines from an engineering point of view in the show.

Magnetos seem to be considerably smaller and more carefully protected from wet and dirt than they used to be. Still, however, one frequently finds them put down in front of the bottom of the engine crank-case exposed to all the mud possible, in spite of the fact that other makers find it quite easy to put them out of the way at the back of the cylinder. Carburettors also appear neater than the earlier designs. With a few honourable exceptions, principally met with on the machines of the old-established makers such as the Zenith, Douglas, Triumph, &c., the petrol tanks seem to be quite needlessly unpleasing to the eye, though perhaps not very much more so than the frames with which they are associated. The finish of the machines is quite up to pre-war standard, but one notices a greater tendency to avoid nickel-plating and so to simplify maintenance. Mechanical lubrication of engines is finding greater favour and electric lighting will probably also supersede the acetylene lamp entirely.

As regards machines which do not come under the heading of motor cycles in the generally-accepted sense of the term, there are two different types at the show. The first, the "scooter," is really a motor bicycle with very small wheels, about 16 in. or 18 in. diameter and a very much dropped frame, on which a platform is carried. The original idea of the device was that the driver should stand, but now seats are fitted and it is very difficult to see that the machine has any advantage over the more usual vehicle, except that it is somewhat cheaper. Its disadvantages are obvious, and time alone will tell whether it is not doomed to be numbered with the "monocycles" and other freak designs which have been advocated in the past. For the everyday purposes of the ordinary motor cyclist it has no recommendations, and it is possibly a false idea of its greater simplicity which appeals to a certain section of the public.

Three types are exhibited, the "Whippet" with a 1½-h.p. four-cycle vertical engine on the platform in front of the rear wheel, the "Silva" with an engine of about the same size fixed at the side of the front wheel, and the unhappily-named "Scootamota," the engine of which is horizontal and is mounted directly over the back wheel, which it drives by a chain. This divergence of design is

typical of the motor-cycle industry as a whole.

The "motorised bicycle," in which the engine is an auxiliary attachment to a practically standard push-bicycle has passed through various forms, but by far the most attractive arrangement yet devised consists of a small self-contained power plant mounted on the luggage carrier and connected to the back wheel by means of a chain. The engine is extremely accessible and well out of the way of the mud. In the "Simplex" auxiliary attachment the 1-h.p. engine is of the two-cycle horizontal type, and in its aluminium base are contained the countershaft clutch, magneto and petrol tank. The whole of the control is from the handle-bar of the bicycle by means of Bowden wires, and the bicycle itself needs no alteration except the addition of an extra sprocket wheel to the hub of the back wheel. The appearance of the whole arrangement is most satisfactory.

One may be permitted to hope that the British motor cycle manufacturers have learnt something from munition work and are devoting themselves seriously to quantity production, but there is little evidence of it at the show. Every firm gives lip-service to the phrase, but few indeed exhibit models designed to facilitate cheap and rapid manufacture in quantities. Furthermore, when one finds individual makers shewing such a variety of types, sizes and powers as appear on some of the stands, it affords reasonable evidence that the economic advantages of concentration upon a single type are not fully realised. Trifling alterations from earlier models, made, one might almost think, if not for the sake of alteration, merely to provide some little thing for the salesman to talk about, are too frequent. Fashions will pervade the engineering world to a certain extent, as they do other branches of activity, but articles which are primarily utilitarian should be freed from the handicap and expense of conformity to passing whims as far as possible. Nobody doubts the value of artistic appearance, yet the canons of beauty do not change with every season, and if the makers of motor bicycles would endeavour to get their industry running on the lines of that of the push cycle from which it sprang, it would be better both for them and for the purchasers. When the present enormous demand for motor cycles of any kind has given place to a greater competition among the makers for orders and a more critical attitude on the part of buyers we may see the industry stabilised along sounder lines of manufacture and design than it seems to be at present.

The show closes to-morrow, Saturday, November 29, at 10 p.m., and is well worth a visit by all who are interested in the smaller motor vehicles.

NOTES.

Kent Coalfield Developments.

At a meeting of the East Kent Coal Company on Monday last, the chairman, Professor W. Galloway, D.Sc., stated that the reason that the output for 1918 had not exceeded that for the previous year was that a large number of men were withdrawn during the period for military service. The number of men employed had, however, since been increased, so that the output for the week ended the 15th inst. had reached 3,605 tons—a figure which he hoped would be increased by the end of the year. The question of sinking two of the shafts to a deeper seam had been considered, and the necessary mechanical preparations made. The work would be put in hand as soon as a convenient opportunity occurred. We understand, from a report in *The Times*, that there are at present three collieries in Kent producing coal—one at Tilmanstone with an average weekly output of 3,200 tons, another at Snowdown where the weekly output is about 2,600 tons, and a third at Chislet, which, at present, has a much smaller output. A second shaft, however, has quite recently been completed at this latter colliery, and the output is rapidly increasing. At the two former collieries substantial seams are being worked at a depth of 1,500 ft., while that at Chislet is 1,340 ft. deep. Below this, however, there are other seams, varying from 4 ft. to 6 ft. 6 in. in thickness, at a workable depth. Although the exact boundaries of the coalfields have not yet been defined, the known area is said to be sufficient to accommodate from 15 to 20 collieries. Early developments, it is said, are likely in connection with the establishment of an iron industry in Kent. It is claimed that over the whole of the East Kent district there is a 12-ft. bed of iron ore, and Messrs. Bolckow, Vaughan and Messrs. Dorman, Long, who have purchased the old colliery at Shakespeare Cliff, Dover, have made exhaustive tests of the ore at their works at Middlesbrough, and are reported to state that the ore is equal to the best Cleveland. The erection of blast furnaces, it is said, will be commenced shortly, and arrangements have also been made for the construction of coke ovens near the Tilmanstone Colliery. The matter is one of considerable interest at the present time, but with regard to the development of the coalfields, it is hardly necessary to point out that the work has hitherto been considerably hampered by uncertainty as to the attitude of the Government to the coal-mining industry of the country.

Artificial Daylight.

As our readers are probably aware the distribution of energy in the spectrum of most artificial sources of light differs materially from that of daylight and, as a result of this, colour values which agree in the former, are altered considerably when transferred to the latter. In some cases, for example with the common form of mercury vapour lamp, the difference is so great that the appearance of certain familiar coloured objects is completely changed when viewed in this light, but even with ordinary artificial illuminants operations involving accurate colour perception are quite impossible. Artists, for instance, cannot paint satisfactorily in artificial light of the usual character, and it was to overcome this particular difficulty that Mr. G. Sheringham tried the effect of simple coloured shades or reflectors in conjunction with ordinary electric lamps. A very great improvement in the quality of light was thereby obtained, and the matter, which was brought to the notice of the authorities of the Imperial College of Science and Technology, was made the subject of a scientific investigation in the Technical Optics Department of that institution. The requisite distribution of colours was calculated by Mr. L. C. Martin and Major A. Klein on spectrophotometric measurements on opaque pigments made by means of Abney's colour-patch apparatus, and, as a result of this work, a shade has been designed, the light from which very closely resembles that from a Northern sky. Lamps fitted with these shades were exhibited by Mr. Martin at a meeting of the Illuminating Engineering Society on Tuesday last, and numerous fabrics, and other coloured objects, were shown illuminated by the Sheringham daylight, as it is called, and also by the light from an ordinary half-watt lamp with a plain white shade. Red and blue fabrics in the former appeared about equally bright, whereas in the latter the red was very considerably brighter. Coloured objects generally had a much redder tinge in ordinary artificial light than in the Sheringham light, and this characteristic is always noticed when tints are compared in daylight and artificial light. The Sheringham lights shown were each made up of a half-watt lamp of about 600 candle-power with an opaque concave mirror suspended under the bulb, and a large conical shade, about 3 ft. in diameter, fitted over it in the usual position. The internal surface of the shade is divided up into patches each about 1 in. square, some of which are left white, and others are painted in various colours. It is on the choice of these colours, and their arrangement, that the quality of the light depends. We understand that the distribution of energy in the spectrum of the Sheringham light is exactly similar to that of daylight except at the blue end, and this deviation is of little consequence since the agreement is good in the brightest parts. There is, of course, a considerable loss of light by absorption in the shade and it is therefore necessary to use a powerful source such as that mentioned above, though smaller lamps might possibly be employed. The large shade, which becomes in effect the source of light, has the advantage that its use eliminates all harsh shadows, so that the light resembles diffuse daylight in this respect, as well as in its colour quality. Such lamps would appear to be extremely useful for shop-window lighting and for industrial work in the textile industries. More unusual applications are perhaps in connection with the matching of artificial eyes and artificial teeth. Very little technical information regarding the light was given on the occasion of the demonstration as it will be made the subject of a paper to be read at a later date, but we may perhaps call attention to the obvious necessity for permanence in the pigments used for colouring the screen. It also seems likely that the results will be affected by voltage variations at the lamp, as well as by the age of the latter, but doubtless these points have received attention.

The Conservation of Oil.

The paper upon "The Conservation of Oil," which Rear-Admiral Philip Dumas, C.B. (retired), delivered before the Institution of Petroleum Technologists on the 18th inst., was read breezily, and was illustrated by numerous asides. It was essentially a protest against the terrible waste of oil and a plea for the internal-combustion engine, the proper place in which oil should be burnt. The lecturer remarked that when Lord Fisher had, in 1912, appointed him Secretary of the Royal Commission on Oil Fuel and Engines, he had known nothing of the subject; he had since studied the question, discussed it with every type of expert, and he had his experience; but he was hampered because the proceedings of the Commission remained secret. There was, indeed, a lack of definite facts in the paper, but not of general criticisms. The annual coal output for the world was 1,250,000,000 tons. Admiral Dumas remarked that of oil 75,000,000 tons was produced, and only 45,000,000 tons of the latter could be converted into oil fuel. Oil was a luxury, but it was wasted everywhere. The education was haphazard; the universities had no proper chairs of geology to investigate the location of oil, and American experts were boring for oil in England. There was little provision made for the immediate storage of any oil that might be produced. The general distribution and availability of oil were remarkably good; but at a certain Mediterranean port he had, during twenty months never seen two tankers which were alike; the nooks and crannies in the double bottoms were a nuisance. The waste of oil in charging tanks on the flying grounds from drums or bins was appalling. The loss of gas from the oil transit was small, only about 1 per cent., yet too large. As regards waste in retail, it might be well to institute a licence before oil could be used in any engine. The greatest wasters of oil, however, were the warships. Admiral Dumas admitted the advantages of oil fuel. For internal-combustion engines oil was to coal as 4 to 1, for geared turbines as 2½ to 1, and those advantages were rather understated. But in the Navy 80 per cent. of the oil went up the funnel, and oil fuel, though indispensable apparently on destroyers and some ships, was unnecessary probably on 60 per cent. of the warships. Nor was it needed in the merchant service in general, where indeed little was used so far, and in any case the price of oil should be raised to its proper height in order to prevent waste. Motor cars could do with alcohol; nobody had yet troubled about the shocking waste of oil in aircraft engines, and lubricating oil was treated almost worse. One could everywhere track a motor—and a ship as well—by the spilt lubricant. This war had largely been waged on oil, the next one would nearly wholly be so. Therefore, find and conserve your oil; use coal wherever possible, but convert it into gas, electricity and liquid fuel at the pit mouths. For one thing, it was time to do away with the wretched poisonous bunker holes on board and the dangerous, dirty mode of charging them. Much more should be done for oil research and for the development of the internal-combustion engine in the country. That the country is not backward in these fields was pointed out during the discussion, and the few definite figures which Admiral Dumas had given, and some of his criticisms of the Admiralty in particular, were repudiated by Sir Marcus Samuel, Sir Tennyson d'Eyncourt, and particularly by Admiral Sir George Goodwin, Engineer-in-Chief of the Navy. The latter asked how

many internal-combustion engines—of 750-h.p. maximum so far—Admiral Dumas would put on a warship and a detroyer of 144,000 h.p. and 28,000 h.p. respectively. Mr. Charles Greenway said that the supply of oil would continue to rise with the demand, to three times its present figure, in the coming years. This may be so. The conservation of oil will certainly remain of paramount importance.

Société des Ingénieurs Civils de France.

The inaugural meeting of the British Section of the Société des Ingénieurs Civils de France was held last Monday, the 24th inst., at the Royal Society of Arts, when Mr. C. H. Wordingham, C.B.E., hon. president of the new section, took the chair. In the course of his remarks, Mr. Wordingham stated that France and Great Britain had been, during the last five years, in close co-operation fighting a common foe; their association in arms had led to similar ones being established in art, literature and commerce, which still further strengthened the ties between the two nations. Engineering had played a most vital part in the late war, and it was clearly evident that it could not be allowed to lag behind; it was therefore thought that a close association should be promoted also between the engineers of both nations. Hence the creation of the British Section of the French Society of Engineers, a society which embraced all branches of engineering activity, civil, mechanical, electrical, mining and metallurgy, administration, &c. Mr. Wordingham gave a short historical review of the French Society since its inception, in 1848, and recalled the fact that several British names could be found in the list of those eminent engineers who had been identified with the work of the society. The British Section would make for a closer intercourse between British and French engineers and works. Mr. Wordingham then introduced the president for the first session, Mr. Guéritte, director of Messrs. L. G. Mouchel and Partners, Limited, who said the object of the British Section was to form a link between the technical institutions here and the corresponding ones in France. It would keep the specialists residing in France posted upon the papers to be read before British institutions, when French technical men could take part in the discussions, thus internationalising the latter, throwing into relief a number of various aspects of the problems under review, and promoting friendship. The Section would also work for arriving at an understanding with the British institutions for the acceptance by the latter of French diplomas with a view to membership, in lieu of British diplomas or examination. It would further promote the exchange for temporary periods of students and young engineers of the two countries. The Section also would read and discuss papers; in this, it would not duplicate the work of existing institutions, for the papers in question would deal only with engineering matters affecting Franco-British relations. In short, the British Section of the French Society aimed at establishing a technical *entente cordiale*. Mr. Gouvy, the well-known French metallurgist, a member of the French Society since 1882 and, also, an influential member of the society's Committee on Mining and Metallurgy, who had been sent specially from Paris by the council of the society to represent them on this occasion, emphasised the necessity of strengthening the union between the engineers of the two nations and added that the present time for the formation of the British Section was most opportune, for competition by the German industries was already most active, and would increase year by year. The council of the society thanked the promoters on this side for their work. In the course of a brief discussion which followed, all the speakers welcomed the new British Section of the French Society. The temporary address of this is 45, Great Marlborough-street, W. 1.

LIGHT AND GRAVITY.

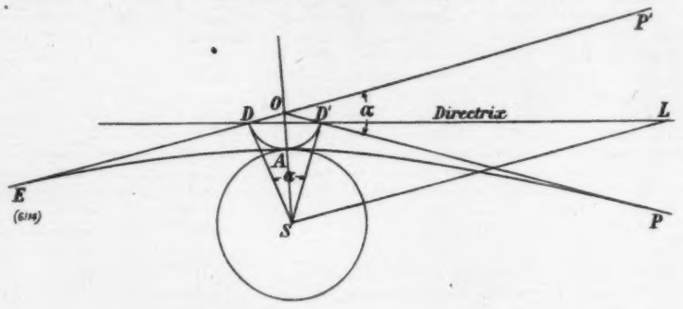
By G. Greenhill.

The revision of our previous notions on Newtonian theories of the cosmogony is the subject of general conversation, and great interest is taken in the photographic results exhibited on Thursday, November 6, at the Royal Society, obtained by the astronomers in the recent eclipse, as a test of the rival theory in the new doctrine of Relativity.

The ray from a star was photographed as grazing the Sun, and from the extent of its bending it is possible to calculate whether the deflection was the amount to be expected on the new theory of Einstein, amounting to over a second and a half of angle, or only about half this amount according to the Newtonian gravitation theory, more exactly 0″·87.

Resuming the Newtonian Problem of Two Bodies, as it was discussed in Engineering, October 11, 1918, page 393, section 2, where the two bodies, S and P, the Sun and a light particle, were a great distance apart in the direction of the star, and moving with relative velocity the velocity V of light, it is easy to calculate the amount of deflection of the light particles forming a ray of light on the Newtonian corpuscular theory in grazing the surface of the Sun, and so checking the figures given in the report of the eclipse.

In the corpuscular discussion, it is immaterial whether we treat light in the modern way as something reaching the eye and coming into it, or adopt the ancient method of supposing light is something proceeding from the eye and enveloping the object seen, and so illuminating it for our vision.



In this second way the light from an eye at E looking through a telescope in the direction E O, would describe the curved line E A P, to reach a star at P, grazing the Sun at A; and the curve would be an hyperbola, with asymptotes E O and O P, if the light particles are taken to be subject to gravity.

Otherwise the light ray would pass along E O P′ to the star at P′ in that direction, undisturbed from a straight line.

Drop the perpendiculars S D, S D′ on E O, O P from S the centre of the Sun, focus of the hyperbola; then D D′ will be the directrix, and S L drawn parallel to E O will be the semi-latus-rectum; and in accordance with the notation given before:

$$L = V \,.\, S\,D,\ G\,(S+P) = \frac{A^2}{l} = \frac{V^2\,.\,S\,D^2}{S\,L}$$

while, if E denotes the Earth:

$$G\,(S+E) = \frac{4\,\pi^2\,.\,S\,E^3}{T^2},$$

where T denotes the year in seconds,

$$T = 10^7 \times 3.156.$$

This makes the grazing velocity V tan ½ (π + α) a little over the velocity of light; and so contradicts the Doctrine of Relativity, where light has the *ne plus ultra* speed of the universe.

Here E and P are so small in comparison with the enormous size of S as to be negligible, and then:

$$\frac{V^2\,.\,S\,D^2}{S\,L} = \frac{4\,\pi^2\,.\,S\,E^3}{T^2} = \frac{4\,\pi^2\,.\,S\,A^2}{T^2}\ (\text{cosec}\,.\,\text{semi-diam.})^2$$

Take the ⊙ semi-diameter at 16′, cosec 16′ = 215 = al 2·3324, and the ⊙ parallax at 8″·8, cosec 8″·8 = 23,400 = al 4·3699; the quadrant of the meridian Q = 10,000 km., and the velocity of light V = 300,000 km./sec. = 30 Q.

The length V T is the "light-year" of Astronomy in kilometres, and is the unit of length employed in recording the conjectural distance of a star; and the light-year in quadrants is V T/Q = 30 T = $10^9 \times 9{\cdot}468$; and then:

$$\left(\frac{V\,T}{Q}\right)^2 = \left(\frac{2\,\pi\,.\,S\,A}{Q}\right)^2 = \frac{S\,L\,.\,S\,A}{S\,D^2}\ (\text{cosec}\ 16')^2,$$

where

$$\frac{2\,\pi\,.\,S\,A}{4\,Q} = \frac{\text{circumference of sun}}{\text{circumference of earth}} = \frac{\sin 16'}{\sin 8''\,.\,8}$$

$$\frac{S\,L\,.\,S\,A}{S\,D^2} = \left(\frac{V\,T}{Q}\right)^2 \frac{1}{16\ \text{cosec}^2\,8''\,.\,8\ \text{cosec}\ 16'} = 10^8 \times 4.744.$$

In the figure, the ray is bent through an angle α = P O P′ = D S D′ = 2 D S O; and

$$\frac{S\,L}{S\,D} = \cot \tfrac{1}{2}\alpha,\quad \frac{S\,A}{S\,D} = \frac{S\,O - O\,D}{S\,D} = \sec \tfrac{1}{2}\alpha - \tan \tfrac{1}{2}\alpha$$

$$\frac{S\,L\,.\,S\,A}{S\,D^2} = \text{cosec}\ \tfrac{1}{2}\alpha - 1$$

so that we may take

$$\text{cosec}\ \tfrac{1}{2}\alpha = 10^5 \times 4.744,$$

and expressing α in seconds,

$$\alpha = 2 \sin \tfrac{1}{2}\alpha \times 206{,}265 = \frac{2'6{,}265}{10^5 \times 2.372}$$

$$= \text{al}\ 1.9393 = 0.8696,$$

say 0″ . 87, as stated.

This theory will serve for the motion of a meteorite striking the Earth at any angle and with great velocity and not merely grazing or ploughing it horizontally; so that if falling vertically through the atmosphere, it would be treated on bomb-dropping theory as if projected vertically downward with velocity greater than its terminal velocity in the air.

This is on the corpuscular theory of light, which has lately come to the front again.

An ether is required on the undulatory theory, but there was always the difficulty that the ether pervaded all space and matter, and yet never partook of its motion, or revealed any drift. In the words of Young, the ether behaves like the wind through a grove of trees.

The Einstein theory is intended to clear up this difficulty, by introducing a new set of axioms of space and time, more general than those we have been able to evolve from our limited parochial outlook on Nature, imprisoned on the surface of the Earth.

The connection of light and gravity is not a new question, as it was discussed in the last century, enough to attract the witty attention of a writer in *Punch*, summarised in what he called Beams in the Balance. "If light has weight, it stands to reason the weight of light is no light weight; so it is no longer a paradox to say, light is heavy."

INDUSTRIAL NOTES.

Writing in *The Labour Gazette*, the Minister of Labour states that employment at the beginning of October was affected by the railway strike, which resulted in a large amount of unemployment in the coal-mining, pig-iron and iron and steel industries, though many trades were not seriously affected. After the resumption of work by the railwaymen on October 6, the strikes of ironmoulders and of steel-works bricklayers in Scotland continued to cause much unemployment in the iron and steel, engineering, shipbuilding and other branches of the metal trades. In other industries employment was usually good or fairly good. Changes in wages which came into operation in October resulted in increases being obtained by about 500,000 workpeople. The general level of retail prices of food and other items at November 1 was about 125 per cent. above the pre-war level, as compared with 120 per cent. a month earlier. The number of out-of-work donation policies lodged at October 31 was 479,427, as compared with 403,003 on September 26. This increase is largely, though not entirely, due to the strike of ironmoulders. The distribution of the 479,427 policies lodged on October 31 was as follows: Civilians—men 94,058, boys 7,349,

women 30,940, girls 2,838. Demobilised—men 340,244, women 3,998. The number of men on the live registers of the Employment Exchanges on November 7 was 478,638, or an increase of 25,291 on October 10; and the number of women was 85,498, or a decrease of 11,559 on the total on October 10. The number of vacancies unfilled on November 7 was 28,796 for men and 42,884 for women, the corresponding figures for October 10 being 34,178 and 43,600. Trade unions with a net membership of 1,407,491, excluding those serving with H.M. Forces, reported 2·6 per cent. of their members as unemployed at the end of October, 1919, as compared with 1·6 per cent. a month earlier, and 0·4 per cent. a year earlier. The level of unemployment indicated by the percentage 2·6, though higher than in recent months, is no higher than that obtaining in a good year before the war.

The following notes refer to the state of employment in the various industries after the immediate effects of the railway strike had passed away. Employment at coal mines in October continued good; the number of workpeople employed at the collieries included in the returns was slightly greater than in the previous month and 23 per cent. greater than a year earlier. At iron mines and at quarries employment continued good, at tin mines it was dull and at lead mines it varied according to the district. The majority of shale mine workers were idle for a considerable part of the month in consequence of preparations made to meet a threatened stoppage arising from a dispute. In the pig-iron industry employment was good on the whole, and the number of furnaces in blast was about the same as at the end of August, though 20 per cent. less than a year ago. Employment at iron and steel works was adversely influenced by the strike of ironmoulders and, in Scotland, of steel-works bricklayers, and the aggregate number of shifts worked in the week ended October 25, was 5½ per cent. less than a month earlier and 9 per cent. less than a year ago. The strike of ironmoulders had a still more serious effect on employment in the engineering trades; the number of out-of-work donation policies lodged by workpeople in these trades was 65 per cent. higher on October 31 than on September 26, and there was also a large amount of short time. Employment in the shipbuilding trade was also affected by this strike, and, in some districts, by the cancellation of Government orders, and it declined to fair. In the tin-plate trade employment improved and was good. In the other metal trades it was fairly good, on the whole, but affected in many branches by the ironmoulders' strike. In the cotton trade employment was fairly good in the spinning section and good in the weaving section, thus showing some improvement on a month earlier. In the woollen and worsted trades employment continued good; towards the end of October the worsted trade, especially, improved as a result of overtime being worked by the woolcombers. Employment remained good on the whole, in the building, woodworking and furnishing, brick, cement, pottery and glass trades. In the paper, printing and bookbinding trades it was, on the whole, about the same as in the previous month, varying considerably between different branches and places.

The changes in rates of wages reported to the Department as having come into operation in October resulted in an increase of nearly 100,000*l.* in the weekly wages of about 500,000 workpeople. The principal increases affected workpeople in the woollen and worsted industry in Yorkshire, and tramway and omnibus employees. Changes in hours of labour in October affected about 7,000 workpeople, whose recognised working time was reduced by an average of nearly 7 hours per week.

Speaking in Sheffield last Sunday, Mr. C. T. Cramp, President of the National Union of Railwaymen, said the Union were now considering wages figures submitted by the Government, which were in some cases 5*s.* or 6*s.* per week better than the previous offer. He would not say whether they would be accepted as final. He was not sure whether it would not be necessary before long to make an application for an increased war wage, irrespective of the present negotiations. On the question of joint control of the railways, Mr. Cramp said the step the men had won was an admission of a principle, the operation of which would give the workers an opportunity of gaining the necessary experience in carrying on an industry such as the railways which would qualify them for assuming entire control ultimately. He was looking forward to a new organisation formed out of the experience through which they had passed which would include all railwaymen, though on a different basis.

On the 13th inst. the Friendly Society of Ironfounders, the Amalgamated Society of Coremakers, and the Iron, Steel and Metal Dressers' Trade Society, sent the following letter to the Engineering and National Employers' Federation:—"We are instructed by the Joint Councils of the Friendly Society of Ironfounders, the Amalgamated Society of Coremakers, and the Iron and Steel and Metal Dressers' Trade Society to approach you with a view to seeing whether your Association is prepared to meet us in conference to consider our application, dated August 1, 1919, for an advance of 15*s.* to journeymen, 7*s.* 6*d.* to apprentices over 16 years of age, with equivalent increases to piece and lieu workers. Our Joint Council feel that your Association will now raise no objection to granting us a conference to discuss our application, having in mind that the Court of Arbitration has sat and issued their award. We have in mind that, prior to the Interim Court of Arbitration sitting, your Association in conference expressed its willingness to negotiate with us on the terms of our application so soon as that Court had given a decision in respect to the application of the other engineering sections. We shall be glad to have your early reply, and thank you in anticipation of same."

Last Friday the secretary of the Employers' Federation replied as follows:—"I am desired to point out that the application for an advance of 15*s.* per week to journeymen and 7*s.* 6*d.* to apprentices over 16 years of age, with equivalent increases to pieceworkers and lieu workers, is not at the moment at issue between us. The position is that during the currency of an award your members have thought fit to go on strike. In addition, two strikes which were commenced prior to the present general strike are still in existence, these strikes being against the employment of moulders belonging to a trade union other than the Friendly Society of Ironfounders.

"Further, statements made by, and on behalf of, the strikers during the strike have made it clear that on the resumption of work difficulties will be raised against the employment of men not members of the Friendly Society of Ironfounders. The members of the unions concerned in the two strikes referred to, as well as those involved in the general dispute, must resume work on the terms existing when they went on strike. Any alteration in wages, and also the adjustment of future working conditions, shall be the subject of discussion after resumption of work takes place."

With regard to the strike of ironmoulders in Scotland, which was to have commenced last Wednesday (see page 681 *ante*), we are informed that at a meeting held last Tuesday of the Associated Ironmoulders of Scotland, it was decided not to proceed with the strike; instructions were sent to all members to withdraw their notices. No explanation of this step has been given.

Mr. Lewis, acting president of the American Miners' Union, on behalf of the bituminous miners, has accepted the proposal of Mr. Wilson, Secretary of Labour, for a wage advance of 31·61 per cent. for day labourers and of 27·12 per cent. for diggers. In explaining the basis of his suggested wage scale, Mr. Wilson declared that the cost of living had advanced 78·80 per cent. in mining districts. It was stated that the mineowners have declined to meet the increases to the miners proposed by the Secretary of Labour, unless the Government, as represented by Mr. Garfield, the Fuel Administrator, assume responsibility for the added burden to consumers. The result is a deadlock, and it is reported that the United States Government is considering the advisability of taking over the mines.

The International Labour Conference has held its sittings at Washington during the last weeks, and an official communication states that the following points have been settled in committee and are to be put before the Conference for final approval:—

The adoption of the eight-hour day and 48-hour week principle, with the exception of (*a*) where less than eight hours are worked on some days of the week, the hours not worked may be redistributed on other days, but with no day to exceed nine hours; and (*b*) that in continuous processes the limit should not exceed 56 hours a week; all overtime to be paid not less than time and a-quarter. The labour employed in the devastated regions of France and Belgium is to be considered as employed under special conditions. This agreement cannot, of course, lower any higher standards established by law or collective agreement.

The prohibition of work in industries between 10 p.m. and 5 a.m. for all women through the substitution of a modernised and enlarged convention for that adopted at Berne in 1906.

The prohibition of the employment in industry of children under 14 years of age, except that Japan has agreed, and India has been asked, to raise the limit in their respective countries from nine to 12, with 14 as the eventual standard.

A special Commission has dealt with the limitation of hours of work in Eastern and other special countries which were fully represented at the Conference, and is recommending considerable reductions in the present hours of employment, with a definite maximum in each case.

Special reports are to be received on unemployment, the employment of women before and after childbirth and the employment of children at night.

Sir Kingsley Wood, M.P., speaking last Monday at the Federation Hall, Abbey Wood, Kent, to a meeting of the Amalgamated Society of Engineers on "Industrial Problems of To-Day," said that the proceedings of the International Labour Conference were not receiving the attention they deserved. The unanimous finding of a Committee of the Conference, he said, prohibiting women's work between 10 p.m. and 5 a.m., the abolition of child labour under 14 and the adoption of the principle of a 48-hour week, would be of world-wide importance. A League of Classes was as necessary as a League of Nations. He could not understand certain Labour leaders enunciating such principles as were involved in a League of Nations, and when it came to applying them to industry at home either shying at them or discarding them altogether. They wanted some compulsory machinery, he said, to prevent war, but when it came to industrial warfare some trade unionists, with much inconsistency, clung to the weapon of a lightning strike.

Contracts.—Messrs. Marshall, Sons and Co., Limited, Gainsborough, announce that they have received an order from the Yorkshire (West Riding) County Council for four 10-ton compound steam road rollers, four "Marshall" patent quick-lift scarifiers, and four living and sleeping vans.

The late Mr. William Hamond Bartholomew.—We regret to have to announce the death, which occurred on the 19th inst., at Ridgeway House, Headingley, Leeds, of Mr. William Hamond Bartholomew. Mr. Bartholomew was born at Bradford, on January 30, 1831, and in 1852 he entered the engineer's department of the Aire and Calder Navigation Company. For twenty-three years he was general manager and chief engineer of that company, and, subsequently, for twenty-four years, a director. He had been of late in failing health and retired from active participation in the affairs of the company last spring. Mr. Bartholomew was an authority on canalisation and inland navigation, on which subjects he was frequently consulted. He was, since February, 1858, a member of the Institution of Civil Engineers.

White-Forster Boilers and the United States Navy.—Messrs. J. Samuel White and Co., Limited, East Cowes, Isle of Wight, have received official intimation from the New York Shipbuilding Corporation, Camden, New Jersey, U.S.A., that 20 destroyers now being built in their shipyard for the United States Navy are being installed with White-Forster water-tube boilers. These torpedo-boat destroyers are each of 1,215 tons displacement, and will develop a guaranteed 28,000 shaft horse-power each, to give them a contract speed of 35 knots. Added to the previous output of over 4,000,000 shaft horse-power, the total in these boilers now stands at well over 4,560,000 shaft horse-power.

Mass Production of Motor Cars.—At an inaugural luncheon given by the directorate of Messrs. Harper, Bean, Limited, the chairman, Mr. H. J. Whitcomb, explained the policy of the concern and the reasons for its formation. It was, he said, an amalgamation of interests for the mass production of motor cars to supply home and foreign markets, and its intention was to reduce the cost of the cars to the public while maintaining a high standard of excellence in workmanship, materials and finish. For this purpose the concern had taken steps to secure adequate supplies of all raw materials and finished products, such as radiators, magnetos, electrical equipment, &c., without which continuity of production would be impossible. Standardised designs had been prepared, and increased plant for mass production ordered, but developments would naturally be gradual. By January next an output of 50 cars a week would be achieved, which, it was hoped, would be increased to 300 a week by July and to 600 a week by December, 1920. An output of 2,000 cars a week was aimed at for July, 1923. The programme included the manufacture of three types only, a small car, a medium-sized car and a commercial vehicle. Of the former 50,000 would be produced annually, and about 25,000 each of both of the latter types. Labour would, of course, play a very important part in the success of the scheme, and for this reason it was essential to give the workers a tangible interest in the results of the company's working. This would not take the form of a bonus or increased wage, but 500,000 fully-paid ordinary shares would be issued, and these would be held by trustees on behalf of the employees as a whole for the purpose of a benevolent fund for them and their dependents. The amalgamation includes Messrs. A. Harper, Sons and Bean, Limited, of Dudley, manufacturers of castings, forgings and stampings; the Vulcan Engineering Company, Limited, of Southport; Messrs. Swift, of Coventry, Limited—both motor car manufacturers; the British Motor Trading Corporation, Limited; Messrs. Hadfields, Limited; and a number of firms engaged in the manufacture of electric lighting and starting sets, jigs and tools, coach work, radiators and accessories. The undertaking, Mr. Whitcomb said, was one of great national importance, as it was the first really effective effort to place the British motor manufacturing industry on a scale of production comparable with the immense activity of the United States.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

To the Editor of Engineering.

Sir,—In my capacity as general treasurer of the British Association for the Advancement of Science, I made, before the Thursday evening discourse at the recent Bournemouth meeting, the following remarks:—

Ladies and gentlemen,—You are aware that after paying printing and office expenses, the funds of the British Association are devoted to scientific research. For more than eighty years we have spent more than 1,000*l.* a year on research, long before ordinary people had heard of research.

Every year we form many research committees; each of them is formed of the foremost men of science of Great Britain, who receive none of the money themselves, and their accounts for mere out-of-pocket expenses are carefully audited. These researches in the past have created some entirely new sciences, have led directly and indirectly to the creation of many new industries, and they have largely produced the world's present natural knowledge. And now to my point. Yesterday, a very prominent member of the Association asked me about our finances. I had to admit that even before the war we were meeting with difficulties due to the increased cost of printing and other things; that, since the war we have been behindhand to the extent of more than 1,000*l.* every year, and that we have never yet asked for the help of moneyed men. The only gift we have ever received from a moneyed man was a voluntary gift from Sir James Caird, who handed me 11,000*l.* at the Dundee meeting. My questioner said we ought to ask for help, and that he was willing to start a fund with a sum of 1,000*l.* At this moment he does not wish to have his name mentioned.

I need not dwell on the importance of our research work, as I feel sure that every person here who has himself done original work shares my opinion that when we limit our expenditure on research, and especially on pure scientific research, we shall begin to be a bankrupt Association—bankrupt, that is, morally from the point of view of science, if not actually in the financial sense.

The moneyed men of Great Britain are most willing to help any good object when they get proof that it really is a good object. We cannot complain of want of their help for they did not know the facts. At the same time, the treasurer of an Association with such a record as ours does not feel happy at the prospect of begging for help.

In the two days of the meeting following that on which I made this statement, the fund was raised to a total of 1,475*l.* I intend to publish in due course a list of names of donors and donations.

To illustrate by many instances (as I might) our claims as to the importance of our researches would unduly prolong this letter, and any selection of a few examples would be unrepresentative. I will cite a single illustration: The National Physical Laboratory, the scene of researches of which the importance to the nation during the war and earlier cannot be over-estimated, had its origin (if its antecedents be traced backward) in the Kew Observatory which was maintained by the British Association from 1842 to 1872, in which period the Association spent some 12,000*l.* on its upkeep.

I am, Sir, your obedient servant,

John Perry.

Burlington House, London, W., November 21, 1919.

"THE BRINELL AND SCRATCH TEST OF HARDNESS."

To the Editor of Engineering.

Sir,—I notice that Dr. Unwin, in his remarks on "The Brinell and Scratch Test of Hardness," in this week's Engineering, suggests that it might be useful to examine the form of the scratch by making a section.

When I read the paper by Sir Robert Hadfield and Mr. Main it occurred to me that it might be possible to obtain a section of the scratch by taking an impression in wax and projecting this optically, as is done in examining ring screw gauges. To test this a small mandrel was coated with wax, and this was rolled on a scratched piece of brass, leaving a minute circumferential thread on the wax. This was then projected under a magnification of about 70 diameters, which showed the form of groove well, the "burr" at the edges coming out clearly. It was possible to trace the outline on paper but, of course, a more accurate record could have been obtained by some photographic method.

I am, yours truly,

W. H. Newman.

Totteridge, London, N. 20, November 22, 1919.

NEW THEORIES OF RELATIVITY.

To the Editor of Engineering.

Sir,—Scientifically-inclined readers of your esteemed Journal must feel indebted to you for the report in the current issue of Engineering of the proceedings at the recent meeting of scientific societies at which the subject of the observational verification of Professor Einstein's prediction was the main theme. Brief as your account is, it has at least the merit of giving actual figures, but for the daily Press, the subject has provided it with one of those never-to-be-missed occasions for disporting its incurable vice of sensationalism, together with a farago of nonsense coupled in some instances with the grossest unfairness to the helpless personality of the "prophet." Indeed, Professor Einstein, however young he may be, would have the rest of his life mapped out, if he endeavoured to rectify all the rash conclusions which have been placed before the public on the strength of the observational verification of his clever prediction.

But whatever has been observed at Principe or Sobral, and subsequently measured in the retirement of calculating rooms of certain observatories, in no way justifies anyone in rashly sacking the "ether," even as an *invented commodity* of the physicist. It appears to me much more likely, that we are on the eve of being made acquainted with a previously unrecognised property of the ether, and of light. The conception of a certain amount of ponderability of the latter became urgent already when the phenomenon of the pressure of light became a demonstrable physical fact, and deflection of a ray of light from an absolutely straight path by gravitational influence is bound to accompany that conception of ponderability.

It becomes very interesting to consider, that practically all photographs of solar eclipses show intrusions of light on the dark disc of the moon at the base of prominences. These intrusions must not be confounded with the Bailey beads where chromospheric light dodges through between adjacent lunar mountains. Photographs of the sun's chromosphere and prominences produced *by artificially* eclipsing the disc of the sun do not show this effect, except very rarely, and in those cases the intrusion may be due to deflection effects, the photographs just indicated being mostly taken in monochromatic light. It appears to me to become a defensible notion, to regard these intrusions of light on the dark disc of the eclipsing moon, as the bending inwards of the light rays coming from these prominences by the gravitational action of the moon.

Moreover, it becomes increasingly probable, that the ether interposed between sun and earth is of different "density" as compared with the ether without the imaginary cone of gravitational lines of force between sun and earth, and the planetary family generally. I venture so far as to consider that intervening portion of the ether as of *greater density** than the average interstellar ether, and incidentally as providing the vehicle for a preference rate of solar heat-radiation from sun to earth and other planets. We have absolutely no proof, that the sun's heat radiation is equal in all conceivable directions radially outwards from the central body, and the conception here advocated would give a much longer radiating, past *and* future, life to our luminary, more in consonance with the postulates of the geologists. This denser ether between sun and earth may also have something to do with the observed fluctuations and irregularities in the moon's motion, as, indeed, already suspected inferentially by Newcomb. Again, the conception of a state of greater density within the more or less sharply-defined cone of gravitational ether stress lines of force, appears to permit of the further conception, that the light coming from stars in the way the Principe and Sobral photographs depict, would enter obliquely an ether stratum of greater density from the outer and less dense ether and thus produce a simple refraction effect much on the same lines as we observe a ray of light to do when passing from air into a denser medium, say, water, glass, &c. This etherial refraction effect may easily be additional to that produced by a gravitational effect pure and simple, and it would become decreasingly effective as the light emanates from stars radially further away from the sun as seen projected in the heavens.

Finally, I presume, we may take it that if the ponderability of light becomes firmly re-established, the effect of momentum at a speed of some 186,000 miles per second has also to be taken into account. Again, is it quite out of question, that the light of the stars, not only passing the eclipsed sun, but also the eclipsing moon, has to thank for some share in the observed deflection to the latter?

Apologising for the length of my letter, and craving your, and your readers', kind indulgence for the sake of the great interest of the subject,

I remain, Sir, very respectfully yours,

Albert Alfred Buss.

22, Egerton-road, Chorlton-cum-Hardy, Manchester, November 19, 1919.

THE EMPLOYMENT OF DEMOBILISED ENGINEERS.

To the Editor of Engineering.

Sir,—I read with interest the letter in your journal from "Ex-Warrant Officer, R.A.F."

That this state of affairs is possible, and my own experience partly bears it out, is a serious reflection on the gratitude and justice of the engineering trade.

I have found the unsatisfactory state of affairs outlined by "Ex-Warrant Officer" to occur more in firms who have largely profited on the war, and who therefore have a staff protected from danger under the Conscription Act. Possibly these staffs say, when they have an application from an ex-soldier: It will be as well not to have him, as his service might influence our directors adversely to us—and thus his application does not get the prominence it deserves.

A case in point, one of my own examples. Through a mutual friend, I got in touch with the directors of a large firm, who told me that I had already applied to them under a "Box" number, but that the application did not give full enough details. Now, being at a depot a few days before being demobilised, I wrote a covering letter saying that for a few days it was not possible to send on specimens, &c. This was not answered or put before the directors. The job went to a man without service in the army.

Yours faithfully,

Ex-R.E., A.M.I.Mech.E.

London, W. 4, November 25, 1919.

*I do not wish to dogmatise as to the point of the ether being possibly "denser" in the direct gravitational cone of sun-earth. All I feel certain about is, that the ether within that region must be under a different *stress* than the ether without, and the interpretation of calling it *denser* therefore appeals to me as an easier explanation of the main-conception.

SOCIETY OF GLASS TECHNOLOGY.

The November meeting was held on Wednesday, the 19th inst., in the Applied Science Department of the University of Sheffield. In the absence of the president, Dr. M. W. Travers, F.R.S., took the chair. The first paper was entitled "*The Reversible Expansion of Refractory Materials*," by Mr. H. J. Hodsman, M.Sc., and Professor J. W. Cobb, O.B.E., and was read by the last-named.

Silica refractories on firing have a permanent expansion, whilst fireclay refractories have a permanent contraction. On subsequent heat treatment both types of refractories undergo expansion which is reversible on cooling. The paper dealt with this reversible expansion. The authors briefly expounded methods of measuring expansion at high temperatures, and described in full the methods actually employed in the particular work under discussion. The range of temperature through which reversible expansion had been investigated was 15 deg. to 1,000 deg. C., and some very remarkable results had been obtained. It was shown that alumina and kaolin expanded regularly within the above temperature range. Silica, whilst having approximately the same mean expansion between 15 deg. and 1,000 deg. C., behaved very differently at intermediate temperatures. Thus between 15 deg. and 500 deg. C. it expanded regularly at a rate slightly greater than that for kaolin. Between 500 deg. and 600 deg. C. its mean coefficient of expansion was greatly enhanced, whilst between 600 deg. and 1,000 deg. C. its expansion was practically nil. The anomalous behaviour between 500 deg. and 600 deg. C. was probably due to a change from α quartz to β quartz. There was nothing in the results to indicate the formation tridymite between 600 deg. C. and 1,000 deg. C.

Curves were shown indicating the behaviour of various materials between 15 deg. and 1,000 deg. C. A mixture of 80 per cent. ganister and clay behaved like silica. Fireclay and potclay behaved similarly to silica, the behaviour being nearer that of silica than that of kaolin, and it was of the nature of the silica curve. Ball clay, alundum and carborundum behaved similarly to kaolin. In conclusion the author discussed the bearing of the results upon the arching and subsequent heating of glasshouse pots and other refractories.

The second paper read was entitled "*A Proposed Standard Formula for a Glass for Lamp Workers*," by Mr. F. W. Branson, F.I.C., and Mr. F. H. Branson, A.I.C. The authors first reviewed their early work of investigation on pre-war tubing for lamp-workers. They then gave an analysis of the tubing they considered most suitable for lamp workers, together with a batch which on melting would give this glass. Tubing had been made from this batch, which was satisfactory in every way. It could be reblown many times without devitrification, and was especially suitable for making plugs, stopcocks, and bulbs. It joined easily with all the best British-made glasses, including the resistant varieties, and was quite suitable for the repair of pre-war imported chemical glassware. The glass was quite free from appreciable colour, and did not darken in the blowpipe flame.

The late Mr. Robert Luke Howard.—We regret to have to announce the death, which occurred on the 15th inst., at his home in Teignmouth, of Mr. Robert Luke Howard. Mr. Howard had been for some sixty years head of the firm of Hayward-Tyler and Co., now Hayward Tyler and Co., Limited, 99, Queen Victoria-street, London, and Luton, Beds. He was born at Tottenham, Middlesex, on October 8, 1834; he served his apprenticeship with Messrs. Fowler and Fry, of Bristol. (Later, Mr. John Fowler established the well-known engineering works at Leeds, now John Fowler and Co., Limited, and Mr. Fry carried on the Bristol business under the name of the Bristol Wagon Company, Limited.) In 1855, Mr. Howard purchased the business which Hayward-Tyler had carried on since 1835—in succession to William Russell, who established it in 1815, and who was connected with Joseph Bramah when the latter invented the hydraulic press and made the first soda-water machines on the continuous principle. Mr. Howard had the advantage of the help of Mr. John Briggs, who had been with both William Russell and Hayward-Tyler. The business developed rapidly under Mr. Howard's care, and in 1863 he was joined by his brother, Mr. Eliot Howard, and subsequently by Mr. Robert Samuel Lloyd and other partners. In 1871 the premises in Whitecross-street, London, where manufacture had been carried on for many years, could not be further extended, and large works were built at Luton, and in 1904 the Whitecross-street works were finally closed and the offices removed to 99, Queen Victoria-street, E.C. 4. In the meantime the business had been greatly developed in various directions. About 1868 the universal steam pump was introduced and became widely adopted, and was followed by the Hayward-Tyler duplex pumps which are now known all over the world. In 1905 the business was formed into a private limited company, Mr. Howard being chairman, a position which he retained until the state of his health confined him to his home in the West of England. Mr. Howard had a strong sense of the responsibility of employers to their workpeople, and he treated his men with unvarying consideration.

HIGH-SPEED TURBINE GEARS.*

By Gerald Stoney, F.R.S.

The function of a gear is to connect two or more pieces of mechanism that are required to rotate at different speeds of revolution. As a rule, each mechanism has a certain speed at which it is most efficient, and has only a moderate range of speed above and below that speed at which it is reasonably efficient; so that unless a sufficiently good compromise can be made between the requirements of the driven and the driving mechanism some sort of gear is a necessity. Thus gearing is necessary to enable the slow-running mill engine to drive the high-speed cotton spindle. On the other hand, direct coupling can be adopted with efficiency between the cylinders of a locomotive and its driving wheels, or between the reciprocating engine of a steamer and the propeller.

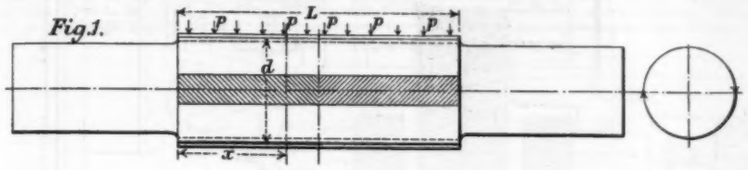
It is interesting to notice, in connection with the latter case, that in the middle of the last century there was difficulty in getting the reciprocating engine of that date to run fast enough for the propeller, and gearing-up was in some instances adopted.*

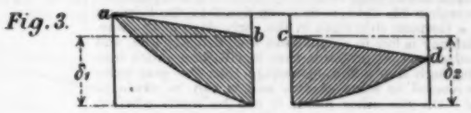
Another interesting example of the advantage of gearing is the bicycle. In the old days of the high bicycle or "ordinary," where direct coupling was necessary, the size of the wheel was fixed by the length of the rider's leg; and the length of the crank, as well as the clearance between the wheel and the saddle, were cut down to a minimum in order to get as large a wheel as possible. Even then, the largest wheel that the average man could use was only 48 in. to 54 in. in diameter—and this with only 5 in. or 5½-in. cranks. With the advent of the "safety," in which chain gearing is used, the wheel was reduced to 28 in., and the "gear," or equivalent size of wheel, is increased to 70 in. or 80 in., the crank being increased to 6 in. or 6½ in. The gain in the more efficient use of the human muscles is much more than the loss due to the inefficiency of the gearing. A further gain is made by the adoption of a variable gear, generally with three speeds, which enables the rider to use the gear most suitable for the gradient, wind, and road surface encountered at the moment.

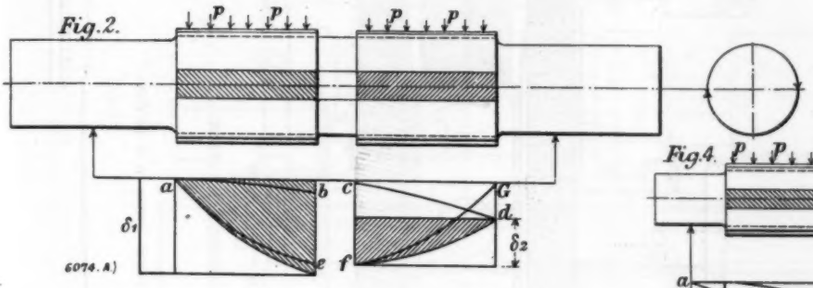
In the early days of the electric transmission of power, chiefly used at that time for lighting, gearing had to be used between the slow-running reciprocating engine and the fast-running dynamo; and this was generally possible and increasing the speed of the dynamo as much as possible, direct coupling became practicable. His first turbo-dynamo, made in 1884, ran at 18,000 r.p.m., and was of 10 h.p.; and it may be said that the design of a dynamo able to run at speeds suitable for a turbine was quite as great an invention as the steam turbine itself. Without this invention, the turbine would never have developed as it has done; and the difficulties in connection with the dynamo were probably greater than the turbine difficulties.

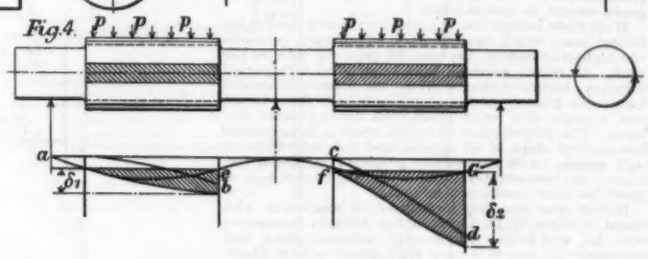
Similarly, when, in 1894, experiments were started by Sir Charles Parsons upon the utilisation of the steam turbine for marine propulsion, the great difficulty was to get the propeller speed sufficiently high to allow of its being coupled direct to the turbine; and it was only after long and costly experiments that a workable compromise was reached. Despite the enormous development of the steam turbine for marine propulsion, one must remember that without gearing it was limited practically to high-speed vessels of over 16 knots, and could not be applied to the great class of cargo ships running from 8 knots to 12 knots. The whole of these difficulties were swept away by the introduction of gearing which enabled both the turbine and the dynamo or propeller to run at their most efficient speeds.

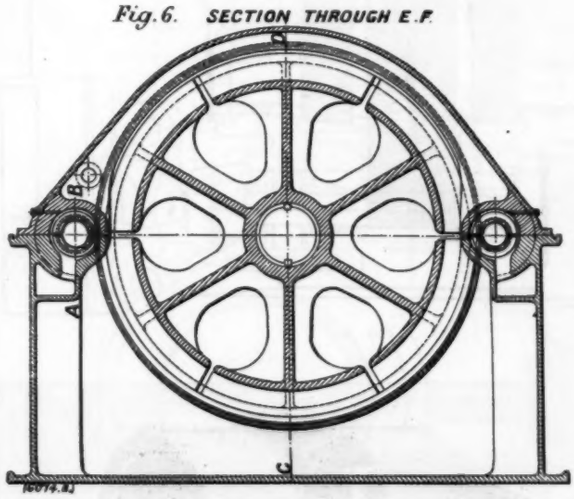
The problem of driving cotton mills and other mills by steam turbines has also been solved by the introduction of gearing. The present position is that gearing is used in all cases for large powers, except in the case of steam turbines driving alternators, where it is found that a satisfactory alternator can be made for speeds suitable to the steam turbine; but even here, for small sizes of,

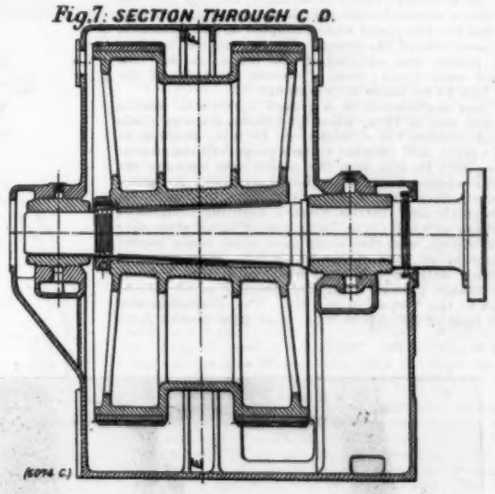


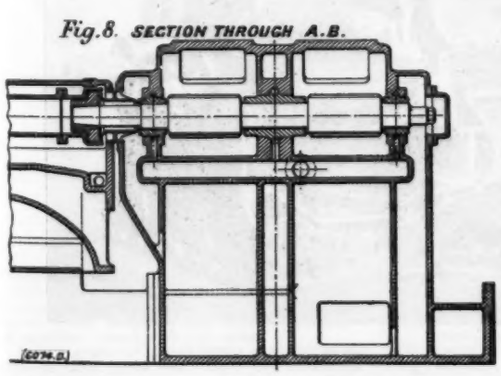












* Paper read before the Manchester Association of Engineers, on Saturday, November 22, 1919.

* See Bourne on "The Steam Engine," page 310.

say, 500 kw. to 2,000 kw., a high-speed turbine is often geared to an alternator of moderate speed.

With reference to types of gearing suitable for use with steam turbines; rope, chain and belt gearing are all impracticable, and the only types used are hydraulic, electric and helical. Ordinary spur gears do not run well at high speeds, and in all cases, therefore, helical gears are used.

Of hydraulic gears, the best known is the Fottinger (see ENGINEERING, vol. xciv, page 804, of December 13, 1912; vol. xcviii, page 60 of July 10, 1915; and page 397 of September 25, 1915); this was fitted to the Königin Luise, a German ship sunk in the early days of the war. Its efficiency is low in comparison with helical gears, and it is not at present probable that it will come much into use, although it has the advantage that the gear ratio can be varied to some extent, and it can be made to reverse. On the other hand, it can be made efficient only for moderate gear ratios. There is also a probable loss in efficiency owing to erosion of the propellers and casing.

The ordinary electric transmission of power from turbo-alternators in power stations to motors is really a case of electric gearing, and need not be dealt with here.

Marine electric gearing, where there are turbo-alternators coupled to electric motors, either on the propeller shafts or connected to them by helical gearing, has been used to some extent on board ship. Its efficiency is low; and it is very doubtful, so far as can be seen at present, whether it will be able to compete with helical gears, except in special cases.

With these exceptions, the gear universally used is the helical gear, which, among other advantages, possesses the highest efficiency, between 98 per cent. and 99 per cent. All recent warships have been fitted with geared turbines; turbine-driven ships for the mercantile marine have such gearing, and it is probable that there is not now a single ship being fitted with direct-coupled turbines. The introduction of helical gearing in large sizes has enabled ships of all speeds, and not only those of high speeds, to be successfully propelled by steam turbines. In this country alone some 16,000,000 h.p. of gears has been made, or is on order.

Helical gear was first introduced in connection with steam turbines by De Laval, about 1889, in connection with his well-known single-stage turbine, which had necessarily to run at a very high speed—about 30,000 r.p.m. for a 10-h.p. and 10,000 for a 300-h.p. turbine. There was a single double helical pinion on the turbine shaft, and two low-speed wheels coupled to two dynamos, one on each side of the pinion. By this device, bending of the pinion was avoided if the loads on the two dynamos were equal; but, of course, the twist of the pinion had to be taken into account.

The first application of a geared turbine to marine propulsion was in 1894, when Sir Charles Parsons made a geared turbine for a launch of 10 h.p., running at 33,000 r.p.m., and coupled to two propellers running at 1,500 r.p.m. In this case the pinion was between the two gear wheels, as in a De Laval turbine. At about the same time a 150-kw. turbo-alternator was made for the Newcastle and District Electric Lighting Company; the turbine at 9,600 r.p.m. being geared to an alternator at 4,800 r.p.m., and this plant gave what was a record consumption at that time. Little was then done in connection with geared turbines, until the Parsons Marine Steam Turbine Company decided to fit geared turbines to the Vespasian in 1910. The Vespasian was a cargo boat of about 1750 h.p.; and after careful tests had been made with the original triple-expansion engines, they were replaced by a geared turbine, the same boilers, propeller and propeller shaft being retained. Corresponding tests were then made, which showed an increase of economy of about 15 per cent. Further tests made between sister ships fitted with reciprocating engines and geared turbines show from 14 per cent. to 19 per cent. extra economy of coal by the use of geared turbines. The general result is, that the geared turbine (as previously mentioned) has completely ousted the direct-coupled turbine for marine propulsion, and is in a fair way to oust the reciprocating engine, except in small boats. In order to obtain silence and smooth running in a high-speed gear, the utmost accuracy in the cutting of the teeth is requisite. It is not proposed to enter here into details of the methods of cutting gears; but it may be mentioned that there are three principal methods (among others) of generating such teeth. These are: Cutting the teeth with an end miller, as in the Citroen gears; planing or shaping out the teeth, as in Fellow's and Sunderland's methods; and cutting the teeth from a hob, which is really a cutter in the shape of a worm. The two latter processes have the advantage that the teeth are automatically generated from a straight-sided cutter. The last-named process is almost universally adopted, and it may be mentioned is used in the gear-cutting machines made by Messrs. Muir and Co., of Manchester, who have supplied large numbers of machines for this purpose.

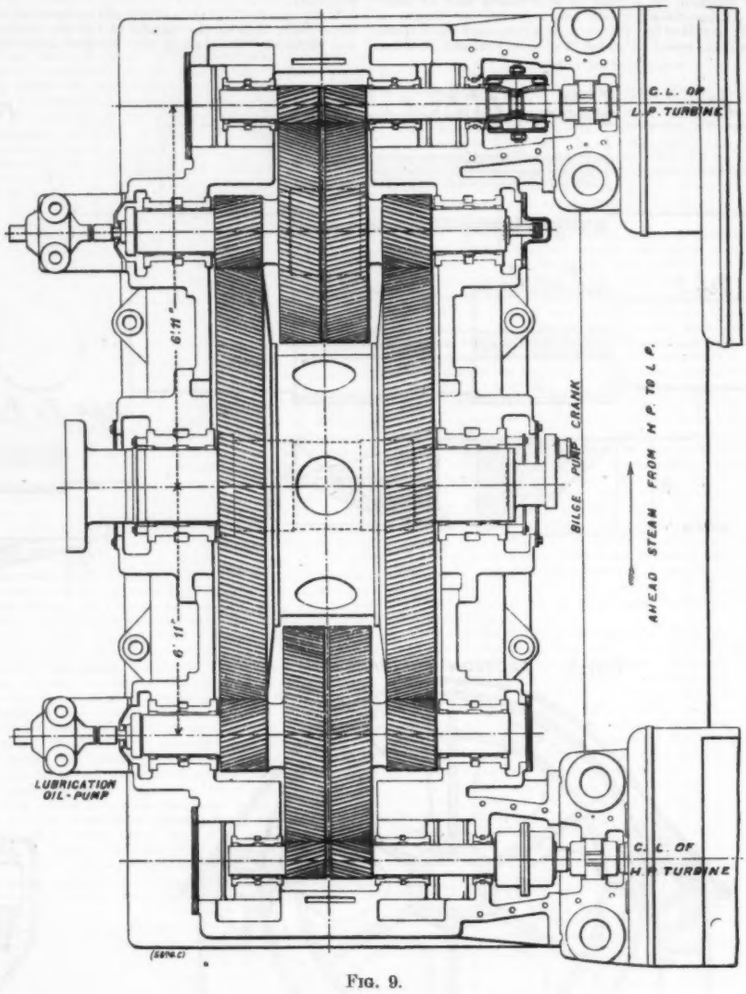


FIG. 9.

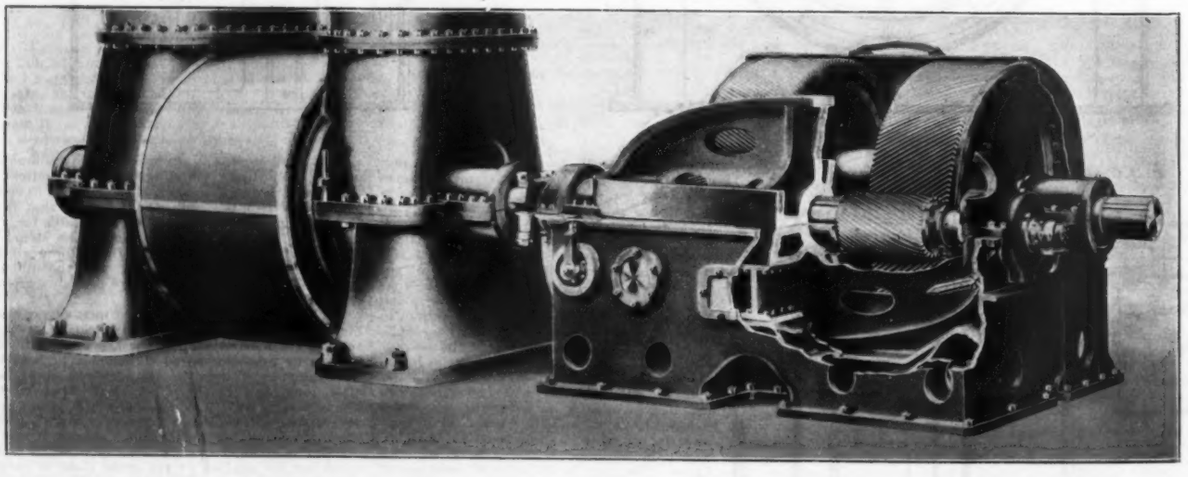


FIG. 10.

At first, considerable trouble was caused by the fact that the master worm wheel, which rotated the gear wheel, was not quite accurate; and this difficulty caused Sir Charles Parsons to devise what is known as the "creep," where the gear wheel to be cut is caused to rotate at a slightly higher speed (about 10 per cent.) than that of the master worm wheel. By means of this device, the errors are not only reduced to about one-eighth, but are distributed in spirals on the gear wheel, instead of being parallel to the axis—a most important point. Even if the master worm wheel is true to begin with, it tends to wear out of truth, and the effect of such wear is minimised by the creep. As a result, this addition to the ordinary gear-cutting machine has been very largely adopted, and of the gears at present in use in this country about 85 per cent. have been cut on machines fitted with the creep.*

Helical gears for geared turbines are invariably made with involute teeth, which have this advantage among others, that the centres can be slightly varied so as to give the desired clearance between the teeth—for it is found that this must be suitably adjusted so as to be neither too little nor too much. Another point is, that such gears can be generated from a hob with straight sides, thereby securing simplicity and accuracy in manufacture. The angle of the hob varies somewhat in practice; but usually the angle of obliquity of the tooth adopted is that of the Brown and Sharpe tooth, namely, 14½ deg. It is requisite that the bottom of the tooth be well rounded and have no sharp angles; and it is surprising that this precaution is so often neglected in gears of all classes. The angle of the tooth relative to the axis of the first gears was about 23 deg., but 45 deg. has been very largely used; for the larger angle has been found to conduce to silent running. There seems to be a general opinion, however, that 45 deg. is rather too large; and the angle now generally adopted is about 30 deg.

With reference to pitch; fine pitches seem in most cases to give more silent running at high speeds; and a normal pitch, that is, the pitch measured at right angles to the teeth, of 0·583 in. (or $\frac{7}{12}$ in.) has been largely used in this country, with about 0·4 in. for small pinions or where extreme silence is of importance. In the United States larger pitches, of 0·9 in., or even more, are often used.

The minimum number of teeth in a pinion is 19, with normal addendum and dedendum; but 22 to 25 is preferable. A peculiarity of involute gear is that by varying the addendum and dedendum interference can be avoided, and thus smaller numbers of teeth than these can be used in certain cases.

The whole gear must be supplied with an ample amount of oil, which is generally squirted under pressure from nozzles against the teeth where they come into contact with one another. This large supply of oil is necessary not only to lubricate the teeth but also to carry off the heat that is generated, and it is usual to have ¾-in. to $\frac{7}{16}$-in. nozzles of about 5-in. pitch, squirting oil under a pressure of 10 lb. to 20 lb. per square inch on to the line of contact between the gear wheels. The quantity of oil is about 1 gallon per minute for each 100 h.p. to 150 h.p. transmitted. The gear-case must be well drained, for if the wheels were allowed to dip into oil at the bottom much heat might be generated by the churning of the oil.

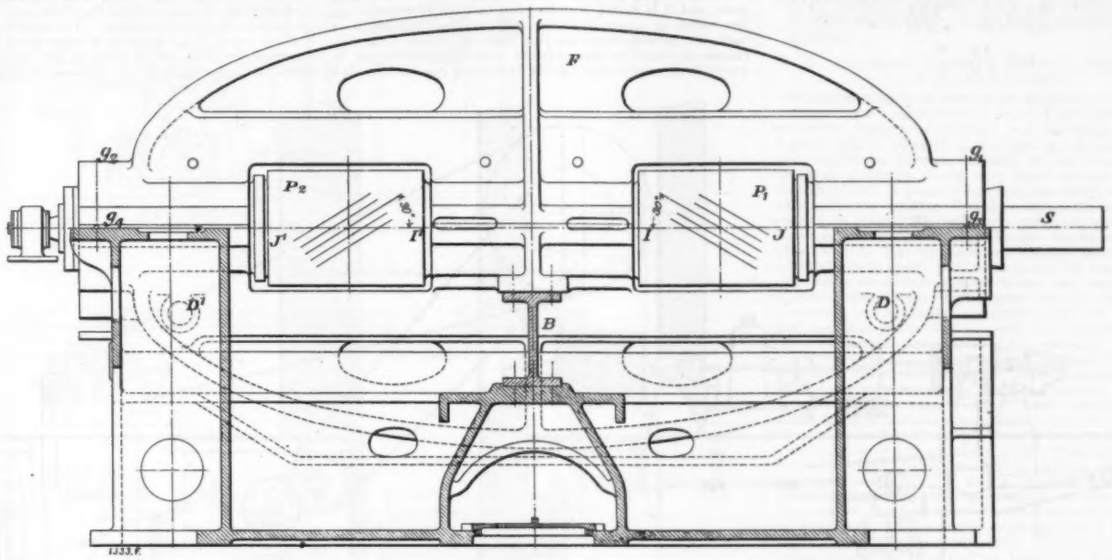


FIG. 11.

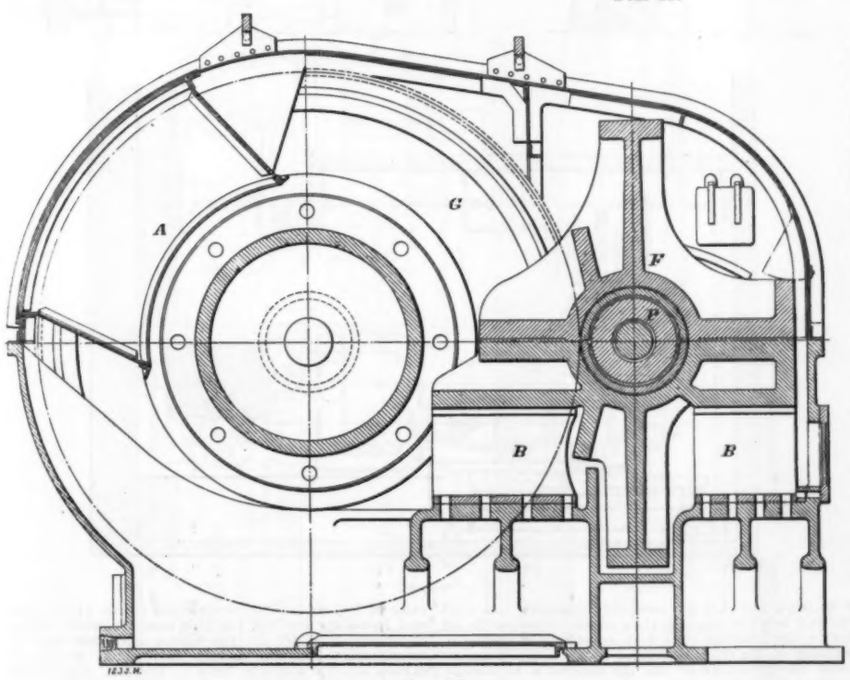


FIG. 12.

The power that can be transmitted by a pinion depends upon the allowable tooth speed, the allowable load per inch run, and the allowable distortion due to the deflection and twist of the pinion, which must be so small that the distribution of load on the teeth remains practically constant. Further, the stresses on the material must be within safe limits. All these limits can only be determined by actual practice, and in this country a conservative policy was very wisely decided on, and as experience was gained the allowable power transmitted by any given pinion was increased. One result of this policy has been that failures of gears have been few and far between; in fact, the gear is quite as reliable as other parts of an installation, if not more so.

Tooth speeds up to 120 ft. per second are common and have in many cases been exceeded. What is exactly the limit of speed is uncertain; but so long as lubrication can be maintained, there does not seem to be any reason why the figure given above should not be considerably exceeded.

The load on the teeth is generally reckoned in pounds per inch run, and is, of course, the same whether per axial inch or per inch of tooth along the helix. It is determined by the safe limit of bending stress on the tooth and of the pressures at the points of contact, as well as by danger of the oil film failing. The bending stresses are in practice very low, and can in general be ignored. For similar crushing stress on the material of the tooth, the load per inch run will vary directly as the diameter; or $p = a\,d$, where p is the load per inch run in pounds, d is the pitch diameter of the pinion in inches, and a is a constant. Similarly, the stress on the oil film will obey some such law as $p = b\,d^n$. The whole theory of the lubrication of gear teeth is a most difficult one, and one that has been only partly worked out. It is not proposed to deal with it here; but reference may be made to a paper by Mr. H. M. Martin in ENGINEERING (vol. cii, page 119, August 11, 1916), in which a reason is given for the assumption often made that $p = b\sqrt{d}$. These two conditions mean that up to a certain diameter $p = a\,d$, and that above it $p = b\sqrt{d}$.

In this country, Messrs. Parsons, who were the pioneers in these gears, very wisely resolved not to exceed $a = 80$ and $b = 175$; but as experience has been gained b has been increased first to 220 and now to 250, and other makers of gears seem to have followed the same lines closely. In America, Mr. McAlpine has adopted a value for a of 105, and has ignored b. He claims to be able to use these high loads by the use of his floating frame gear, which will be described later; but it is only experience that can show whether such a device has any advantage and whether such high loads are safe. It is much better to keep to moderate loads in the early days of such gears; and we are still only in those early days.

With regard to the distortion of the pinion; this is made up of two items—the twist of the pinion due to the torque it transmits and the bending due to the load on the teeth. In estimating these it may be assumed that the load on the teeth is uniform along the pinion—or, in other words, that the torque diminishes uniformly from the driven end to the free end of the

* For further details see Trans. Inst. Naval Architects, vol. lv, part 1, 1913; ENGINEERING, vol. xcv, page 371, of March 14, 1913; and the *Beama Journal*, No. 2 vol. v, April, 1919.

pinion. It may be further assumed that the effective diameter of the pinion is the pitch diameter.

At any point x in Fig. 1, page 729, the torque T is:

$$T_x = \frac{p_x d}{2} = \frac{2fI}{d} = \frac{\pi f d^3}{16}$$

where f is the sheer stress at the circumference of the pinion and I is the polar moment of inertia, or $\frac{\pi d^4}{32}$. Hence it follows that $f = \frac{8 p x}{\pi d^2}$. If N is the modulus of rigidity, which for steel is 12,000,000 lb. per square inch:

$$\frac{dy}{dx} = \frac{f}{N} = \frac{8 p x}{\pi N a^2}$$

$$y = \frac{4 p}{\pi N} \frac{x^2}{d}$$

which is a parabola. The twist in the first half of the pinion is:

$$y^1 = \frac{p}{\pi N} \frac{a^2}{d}$$

and in the second half:

$$y^2 = \frac{3 p}{\pi N} \frac{a^2}{d}$$

There are two cases to consider: The case where there is no centre bearing and the pinion is supported from the ends, as in Fig. 2, page 729, and the case where there is a centre bearing as in Fig. 4, page 729.

The deflection of the pinion can be calculated in the usual way, and is shown by the curves $a\,e$ and $f\,g$. To this must be added the twist, as shown by the curves $a\,b$ and $c\,d$. Adding these together, the total distortion is shown by the shaded area, the maximum distortions in each half of the pinion being δ_1 and δ_2. It must be remembered in estimating these distortions that the pinion is free to move endways. The gap shown in the middle of the pinion is generally necessary to enable the hob to clear the teeth in each half.

It will be seen that in the case of a pinion without a centre bearing the bending or deflection is the chief thing to be considered; while in the case of a pinion with a centre bearing the twist is the chief thing.

The allowable amount of distortion is very small, and in good design does not exceed 1/1,000 in. Of course, the stress on the material due to bending and shearing must be kept within safe limits; but these are generally quite low.

It is easily seen that the alignment of the gears in the gear-case is of the greatest importance, as also is the construction of the gear-case. There are two principal types: The rigid gear-case originally introduced by Sir Charles Parsons, which is the type generally adopted in this country; and the floating frame type introduced by Mr. John H. McAlpine in America.

Figs. 6 to 8, page 729, show a rigid gear having a pinion with a centre bearing, in which the gear-case is a well-ribbed casing so designed as to support the pinion and gear wheel with a minimum of distortion; Fig. 9, page 730, shows a double reduction marine gear, the pinions being without centre bearings. This latter plant is described in ENGINEERING of May 23, 1919, page 666, and was supplied by the British Westinghouse Company. It was for 2,500 shaft horse-power, the turbine running at 3,000 r.p.m. and the propeller shaft at 70 r.p.m. When the reduction ratio is large, it is found preferable to have a double reduction gear. In a gear with a floating frame (Figs. 10 to 12, pages 730 and 731; the pinion is in a rigid frame supported on a flexible support B, in Fig. 10. This, it is claimed, enables the pinion to take up a slightly inclined position, and thus reduces the effect of the distortion of the pinion. It will be seen that if, in the case of a pinion with a centre bearing the pinion took up the position $a\,b\,c\,d$, shown in Fig. 5, page 729, the effect of the distortion of the pinion would be largely reduced. In the case of a pinion without a centre bearing, however, the effect is only small, as shown in Fig. 3, page 729.

As previously mentioned, it is found that in actual practice the principal thing to be taken into consideration is twist in the case of a pinion with a centre bearing, and bending in one without such a centre bearing. The exact angle that such a floating frame will take up is, of course, dependent upon the distribution of load along the teeth; and whether it will be such as to give a minimum of distortion as shown in Figs. 3 and 5, page 729, is a question.

The general practice in this country is to have a rigid gear, and it is found that the distribution of wear along the teeth is quite uniform, without the necessity of such an arrangement as the floating frame. In this regard it must be remembered that the distortions in question are very small, never exceeding one-thousandth of an inch, and that the inevitable elasticity of a rigid gear-box helps to diminish their effect. Besides, the oil film in the bearings is of very considerable thickness, probably of the order of several mils. Little is known about the thickness of the oil film in a high-speed bearing; but there is evidence to show that its thickness is very considerable, and that it must be fairly thick is further shown by the clearance that has to be given in a high-speed bearing. This clearance is from 2 mils. to 3 mils. per inch diameter, and thus is very large in comparison with the distortions to be dealt with. A very small variation in the thickness of the oil film will therefore compensate for the distortion of the pinion.

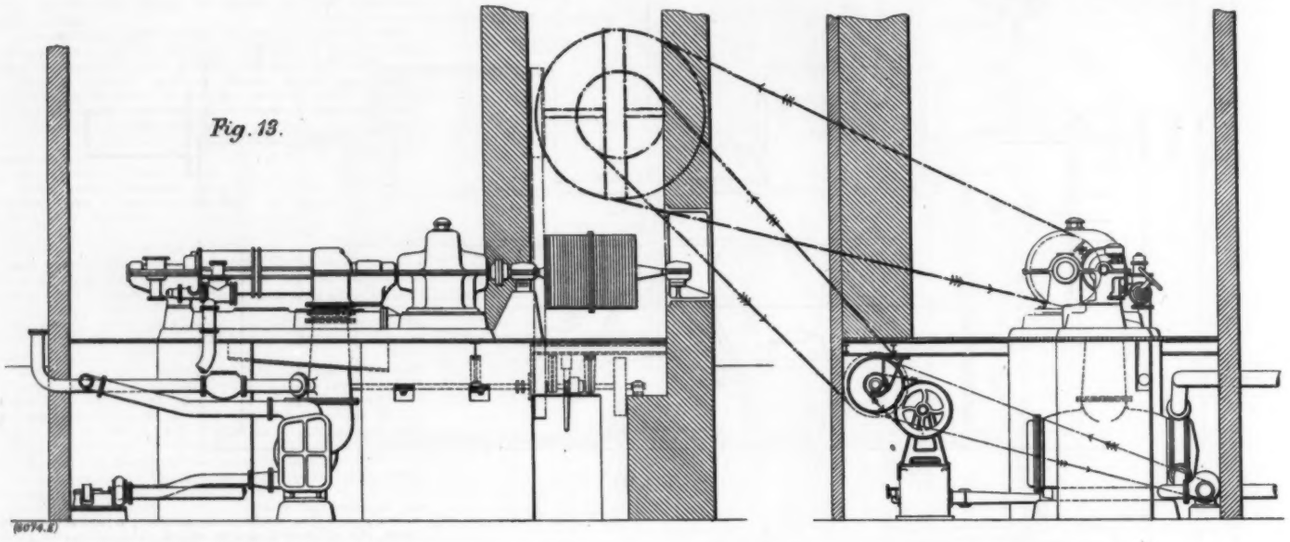
The rigid gear is the usual design adopted in this country; and the experience with some 16,000,000 h.p. of gears that have been constructed or are on order is, that it works excellently and is most reliable and efficient. On the other hand, the floating-frame type of gear is used largely in America, and is said to give excellent results; but it is a question whether such a device is necessary and whether quite as good results cannot be obtained by the rigid gear as adopted generally here. It is claimed that higher tooth loads can be used by the adoption of a floating frame; but only experience can show whether such a claim can be substantiated. Very wisely, the policy adopted here has been to go very cautiously until sufficient experience is gained.

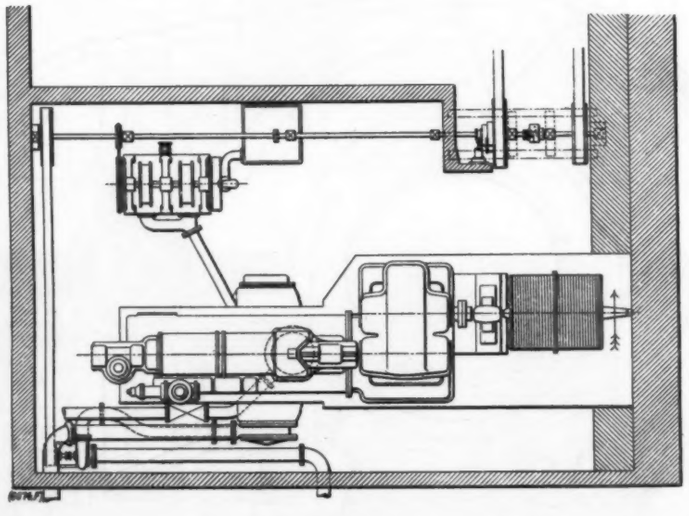
Another type is the Alquist gear, in which the gear wheel is made up of a series of plates so as to give flexibility; but it does not seem to have been much used.

It is not proposed to describe in this paper the application of such gears to marine work, which is, of course, by far the largest application of the geared turbine; but a few typical instances of its application to land work may be of interest.

An example of a geared turbine driving a cotton mill is shown on this page; this was supplied by Messrs. Richardsons, Westgarth and Co., Limited, of Hartlepool, to replace an old mill engine. The speed of the turbine is 3,000 r.p.m., and it drives a rope drum 3 ft. 10 in. in diameter by 4 ft. 10 in. long at 400 r.p.m., through a reduction gear with 24-in. centres, having a reduction ratio of 7·5 to 1. The drum takes thirty 1¼-in. ropes and transmits 700 h.p. In this case the whole of the expansion from 160 lb. per square inch, 200 deg. F. superheat, to 26¾ in. vacuum (barometer, 30 in.), is carried out in a single 700-h.p. turbine. The steam consumption is 13·9 lb. per shaft horse power.

Fig. 13.





The centrifugal circulating pump is on a belt-driven countershaft, and runs at 600 r.p.m., the air pump being driven at 120 r.p.m. from the same shaft by a chain gear.

For starting up, a small vertical steam engine is provided to drive the countershaft by a belt and a claw clutch; when the turbine is up to speed the countershaft is connected to the main mill shafting by a friction clutch, and the steam engine is taken out of gear.

An example of the combination of a geared turbine with a reciprocating engine is shown on the opposite page: it shows a plant by Messrs. C. A. Parsons and Co., Limited, for driving a wire rolling mill, having two shafts running at different speeds. The compound reciprocating engine runs at 80 r.p.m., and is supplied with saturated steam at 160 lb. pressure, originally exhausting into a central condenser at about 14 in. vacuum, giving 2,100 h.p. By allowing it to exhaust at 16 lb. absolute

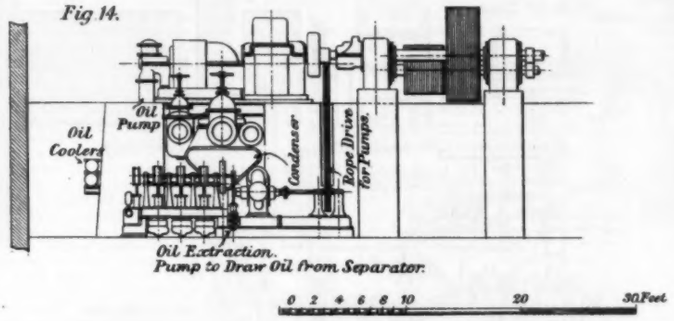
and leading the steam into a turbine, exhausting into a condenser with 28·8 in. vacuum (barometer 30 in.), the engine gave 1,650 i.h.p., and the turbine 1,663 i.h.p., or a total of 3,313 i.h.p., an increase of 58 per cent. in power with no increase in steam used, giving an increased economy of 36·6 per cent. The exhaust turbine runs at 3,700 r.p.m., and the geared shafts at 500 r.p.m. and 250 r.p.m. The difficulty of the uneven turning moment of the reciprocating engine and the even turning moment of the steam turbine straining the gear is met by the flexibility of the rope drive. For starting up, the reciprocating engine can be exhausted to atmosphere.

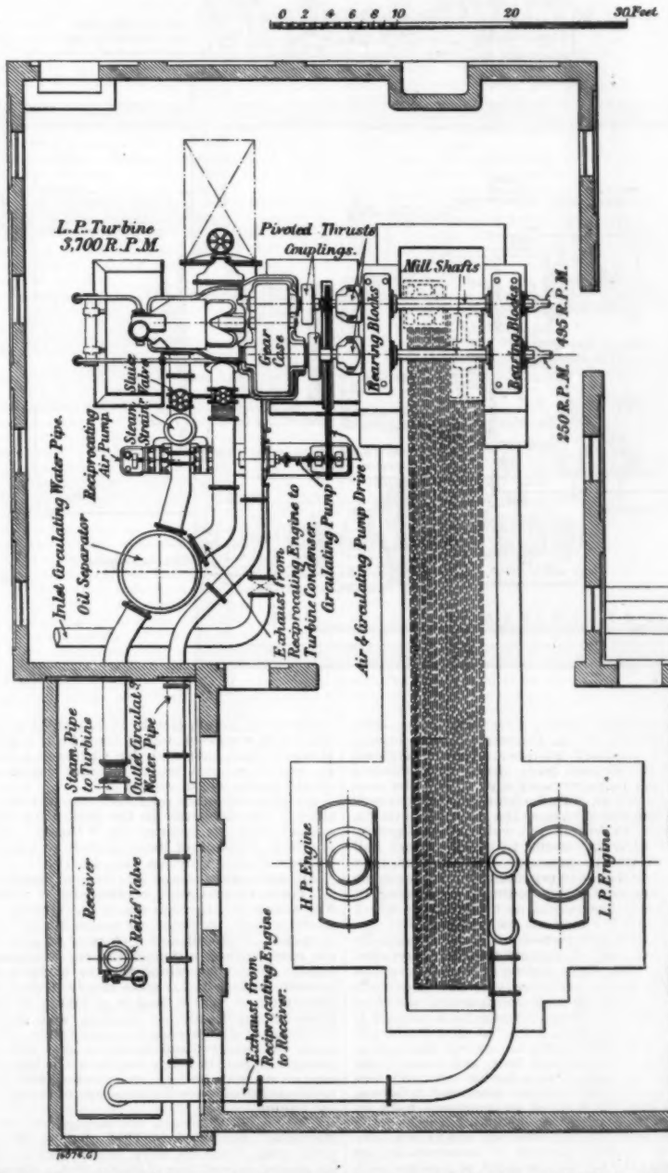
It may be noted that if the power supplied to each low-speed shaft is equal, there will be no bending of the pinion, and the only distortion will be that due to twist.

An example of a mill drive where the turbine is divided into a high-pressure and a low-pressure turbine geared to a single shaft, is shown on the next page. This dividing of the turbine is the usual arrangement in marine geared turbines, and can be taken as typical of the practice in marine work, the details being modified in accordance with marine practice. The example shown in Fig. 15 was supplied by Messrs. C. A. Parsons and Co., Limited, to a large cotton mill in Lancashire, and is of 2,300 brake horse-power normal, with 2,900 brake horse-power maximum. Steam is supplied at 110 lb. per square inch gauge, and 150 deg. F. superheat, and exhausts into a condenser at 27·9 in. vacuum (barometer 30 in.), with cooling water at 80 deg. F. The high-pressure and the low-pressure turbines both run at 3,500 r.p.m., the power being about equally divided between them; and they are geared to the rope pulley running at 250 r.p.m. The steam consumption is 11·1 lb. per brake horse-power hour, as shown by tests made on a brake before despatch.

The author wishes to express his thanks to his colleagues at the College of Technology for the help they have given him in preparing this paper, and also to the various firms that have given him particulars of sample installations that have been supplied. Many other firms have installed geared turbines for land purposes; those shown here must be taken as merely typical of such installations. The author also especially wishes to thank the editors of ENGINEERING for the loan of many of the blocks illustrating this paper.

Fig 14.





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REINFORCED CONCRETE ROADS, THEIR CONSTRUCTION, MAINTENANCE AND LIFE.*

By W. MATTHEWS JONES, M.Inst.C.E., City Surveyor and Engineer, Chester.

IN attempting to write a paper in favour of reinforced concrete road construction, I know I am treading upon somewhat dangerous ground, and am likely to arouse a great deal of opposition amongst my fellow engineers and surveyors because, firstly, we in this country, speaking generally, know very little of such road construction and its possibilities and, secondly, an engineer and surveyor holding a public appointment under a council is subject to so much criticism (often unfair) from the ratepayers at large if new methods go wrong, that more or less he does not diverge from the older systems which in the past have given fair results.

I find it somewhat difficult to put into words all that I should like to say with regard to this class of road construction, inasmuch as opportunity of actual experience has been limited, and the knowledge which other surveyors and myself have obtained has chiefly been acquired by reading papers which have either appeared from time to time in the engineering press, or have been read on the subject in America. However, I hope that my paper will at least initiate a discussion which will throw new light upon the matter and that some good purpose will thereby be attained.

Some nine or ten years ago a road widening in Chester had to be done, and it occurred to me that this would be an opportune time to try a concrete road surface. Accordingly, with the permission of my Highways Committee I laid an area of about 400 superficial yards of concrete. This was not reinforced, and was opened out a fortnight after completion. The surface has stood exceptionally well as a surface, but owing, in my opinion, to it having been opened for traffic too soon and to the lack of reinforcement, it became wavy and bumpy, although it did not actually break up. The whole area was laid 8 in. in thickness, and was on a clay subsoil. Two months after being opened for traffic I was afraid (owing to the waviness) of its breaking up. I therefore covered the surface with tarred chippings. This, in my opinion, obviated the breaking up, although the tarred chippings also became wavy, but not quite to the same extent as the concrete underneath. However, I think that in the circumstances this first experiment stood well, and to-day the surface is not in a bad condition.

The second experiment I carried out was on a main road leading into the town and taking about 700 tons of traffic a day. Perhaps this experiment will not be considered a fair test, but it must be understood I am only giving my experiences. The lengths laid in this case were reinforced; they were 5 ft. wide each and about 50 yards in length; each strip was placed between the tramway margin setts and the kerbs forming the footways. My reason for trying this system here was because I found that neither water-bound macadam nor tar-macadam would stand, and I was continually having to repair these narrow strips. The reinforced concrete surface has stood exceptionally well, and has been down for about seven years. I tar-spray this concrete once a year—if I happen to be in this district with the tar-spraying machine I do it twice. The tar-spray is afterwards covered before it is dry with ¼-in. granite chippings.

In the third case, my committee decided, seven years ago, that one of the streets in the centre of the town should be repaved with wood blocks as the old ones were worn out. The wood blocks were taken up and the concrete foundation exposed. This concrete seemed to be in perfect condition, and I therefore discussed with my assistant the question of concrete carriageways. His reply was that the concrete would crack and break up under any weight of traffic. However, I determined to make an experiment and sent the 12-ton steam roller down the next day, marked out two lines along the centre of the concrete and allowed the roller to traverse up and down 200 times; this meant that 2,400 tons passed over that particular area of concrete without the slightest sign of a fracture being observed. Again my assistant was not satisfied, and suggested that the trial of a vehicle with broad rims like a steam roller was no proof of the effect of a vehicle with narrow steel rims. I agreed, and as a further experiment the next day sent my 1,000-gallon tar-spraying machine (loaded) down to the work. This machine, when loaded, weighs approximately 10 tons, and has to be drawn by the steam roller. It was sent up and down the same track as that used by the roller on the previous day, and again I found there was no sign of cracking or breaking up. The steel tyres of the tar machine are 4½ in. wide. This experiment convinced me of the suitability of concrete as a carriageway surface.

About this time the corporation had served notice on the frontagers under the Private Street Works Act, that a certain road in the district, known as Robert's Lane, should be repaired and put in order, the estimated cost of the work being 1,500*l*. The owners and frontagers

* Paper read before the County Councils Association, at the Roads and Transport Congress, Friday, November 21, 1919.

objected, however, to the work being done at this cost. I then determined to make a bold bid for reinforced concrete road carriageways, and submitted fresh estimates to my committee showing that I thought the work could be done for 960*l*. This scheme was placed before the owners and frontagers and agreed to. The work was carried out for the estimated figure, and, although taking only about 100 tons to 120 tons of traffic per day, this road has given the most complete satisfaction, and is as good to-day as when it was laid. This carriageway actually cost 5*s*. 1*d*. per superficial yard, and the maintenance has, during the past 6½ years, cost the corporation on an average, 1¼*d*. per superficial yard per annum, this being for tar-spraying the surface and covering with chippings. After this I tried one or two small areas in side streets, with the same result.

White Friars was the next carriageway treated, and here again the work was successful, but it was for light traffic only. The cost of this work came to 6*s*. 3*d*. per superficial yard.

My Highways Committee have been so satisfied with these works that they are now allowing me to lay a reinforced concrete carriageway right through the main thoroughfare of the city, viz., Foregate-street and Eastgate-street. This street takes all the through traffic from Manchester, Warrington and Liverpool to North Wales, and I have roughly estimated that there is not less than 1,500 tons of traffic passing over this roadway each day. Along the centre of these streets, is a double line of tramway track, and this is being concreted in at the same time. A portion of the work has been completed and opened for traffic, and up to now the results have been all that I anticipated. Of course, 3½ months' wear is really little to go by, but I have the greatest faith in this work being a complete success. Very careful observations are being made of the work, and in the event of its proving a failure I shall be able, from the statistics obtained, to find the cause and so remedy it in the future. I might add that we received the sanction of the Local Government Board to do this work, and I am happy to say that the Road Board have shown their interest in the experiment by granting my council the full estimated amount for carrying it out, viz., 5,000*l*. I estimated for this work last January, at a cost of 11*s*. 3*d*. per superficial yard, but up to now the cost has been 12*s*. 9*d*. per superficial yard; this is owing to the price of cement going up 8*s*. per ton, granite 1*s*. per ton, a slight increase in the cost of labour, and also to a strike of the men engaged on the work.

If this scheme proves a success I shall ask my committee to allow immediately 8 miles of my roads, which at the present time require reconstructing, to be done in a similar manner. It may be interesting here to say that if the 8 miles of roads are reconstructed with reinforced concrete I estimate the cost will be 13*s*. per superficial yard, making a total of 82,368*l*. If the work were done with granite sett paving on concrete foundation I could not in Chester estimate a lower cost than 25*s*. per superficial yard, or a total of 158,400*l*., or, again, if it were done with tar-macadam, including a foundation, 17*s*. per superficial yard, or a total cost of 107,712*l*.

From these figures it will be seen that a reinforced concrete carriageway shows such a saving that if we can only construct these roads on right lines no other method will, in my opinion, stand a chance.

Perhaps it will be convenient to state here the method adopted for laying this concrete, and other facts, which are as follows:—

When considering the question of reconstructing the main street of this city my committee had a report from me as to two ways in which the street surface (which is at present paved with wood blocks in bad condition) could be reconstructed; one for a reinforced concrete surface, the other for a granite sett paved surface. The former was estimated to cost 5,000*l*., the latter 11,000*l*. These figures showed such a difference that my council agreed that the Highways Committee should try the experiment of reinforced concrete for heavy traffic.

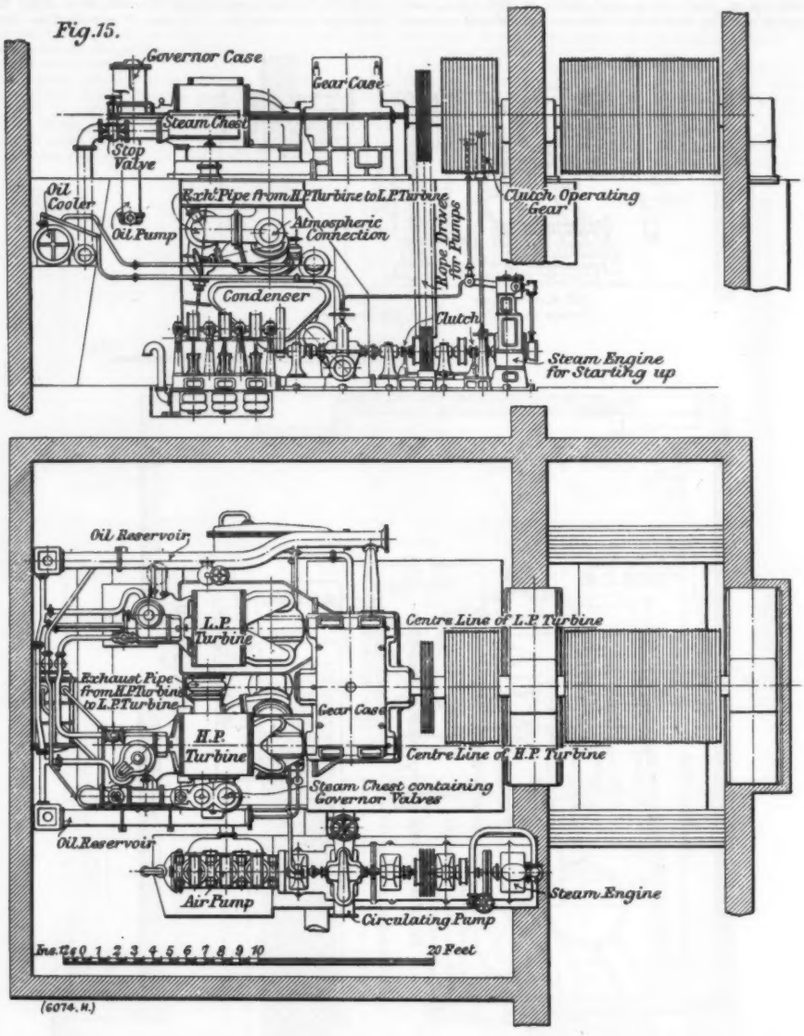
The concrete is mixed in the proportion of 5 to 1. The granite used is of the following sizes: 1½ in., 1 in., ¾ in. and ½ in. These are mixed in equal proportions, as I have come very firmly to the conclusion that it does not do to lay the larger material in the bottom and bring the finer material to the top. The secret in reinforced concrete road construction is, to my mind, to have all the interstices filled; one must have no voids, and I believe that by the mixing of the different sizes we get a perfect mass of conglomeration of the matrix, which is as necessary in a road as it is in a concrete floor or beam. The proportions of the concrete are 3½ of granite, 1½ of clean sharp sand to 1 of cement. The sand must be perfectly clean and free from clay or soil. The cement must be of the best quality to be obtained and medium setting, and in this respect I have been helped by the manufacturers supplying it; they have given me every assistance to get the right material. The reinforcement used is that of a well-known engineering firm, and, as I have stated on many occasions, seems to me to be the best material for the work. I use what is known as their No. 9 fabric. As a rule one does not like, in a paper of this kind, to mention the names of firms supplying the various materials, but on inquiry I will give the necessary information, as it is only my desire to give to my fellow engineers and surveyors and those interested in road construction and maintenance all the facts possible. I am, of course, always open to try some other materials if it is proved that they are better than those I now use. When the concrete surface has been completed—that is, after it has been trammelled to the contour and allowed to set, I tar-spray the surface and cover off with ¼-in. granite chippings.

This concludes my brief account of the work I have had in hand in Chester, and I now propose to touch briefly on works carried out by other surveyors so far as my knowledge extends.

GEARED TURBINES FOR COTTON MILL.

(*For Description, see Page* 729.)

Fig.15.



It will be remembered that between December, 1914, and March, 1915, Mr. H. T. Chapman laid an experimental length of reinforced concrete road near Gravesend, the subsoil of the district being chalk. The concrete was mixed in the proportions of 6 to 1, and the road takes at least 1,000 tons of traffic per day. For national reasons it was impossible to close the roadway to traffic, so it was decided to do half the width of carriageway at a time and allow the traffic to use the other half whilst the work was in progress. This method in a narrow carriageway is not to my liking, but I very much admire Mr. Chapman for his courage in adopting it, and his experiment has taught us many things which we did not know or, if I may say so, understand.

However, the work was carried out under abnormally bad weather conditions. I am told that frost prevailed on many days; when there was no frost, more or less rain was coming down, and everyone who had made a study of this class of road construction therefore came to the conclusion that it would be a wonder if this road stood at all. Events proved that it did not stand, and that when the traffic ran over it the surface soon showed signs of wear and tear, and many holes appeared. The bad places were hacked out and tar-macadam laid on. In spite of this questionable failure, Mr. Chapman, however, decided to commence work on the other half of the carriageway, and on this occasion he was favoured with better weather conditions. He also adopted a different method of construction, for instead of putting the full 6 in. in depth of concrete with a 6 to 1 mixture, he laid the bottom 4½ in. with 6 to 1 and the top 1½ in. with a richer and finer mixture, viz., 3 of grit and sand to 1 of cement. This second portion, which has now been opened for traffic since, I believe, 1915, is as good as it was the day it was laid. This latter method of laying two-coat work is naturally more expensive and tedious than the mixing and laying of the concrete in one body. I am quite convinced, however, and I think Mr. Chapman will agree with me, that if the work of the first half of the roadway had been commenced, say, in March, 1915, instead of ending then, the whole roadwork would have been a great success. However, as I have said, Mr. Chapman has given us all an experience and taught us that concrete roadways should not be laid in winter.

Dealing with other reinforced concrete roads, I do not think I can do better in the first place than give an extract from an address on "Roads" delivered by Mr. R. L. Bendall, of Bournemouth, at a meeting of the Gosport Rotary Club, on July 10, 1919.

Amongst other things Mr. Bendall states:—

"Some of you visit occasionally a picture palace. You see in an American film a fine stretch of road of a white surface; a motor car comes along at a high rate of speed. You will notice there is no dust rising from the road surface, although the car is moving at great speed. That road which the car is going over has a concrete surface and is quite free from dust, as it is free from mud in winter, and is a luxury in road travel. There is practically no camber, and therefore little likelihood of side slipping for horse traffic. This country is an old country, and therefore goes slower than the younger ones. It keeps somewhat in the old grooves, and so we stay and go on spending each year in the maintenance of roads the huge sum of nearly 10,000,000*l*. per annum.

"Mr. H. T. Wakelam, the surveyor of the County of Middlesex, estimated in 1914 that to strengthen the rural main roads to carry heavy motor traffic would involve an expenditure of 80,000,000*l*.; the rural district roads another 184,000,000*l*.; while the roads in urban districts would cost a further 22,000,000*l*. So that in 1914, before the roads had had the excessive war traffic over them, we should have a total expenditure of 286,000,000*l*. to place them in a condition to carry weights of present-day traffic. The mileage of all roads under the control of 2,128 authorities in England, Wales and Scotland is 176,784 miles. The upkeep of a main artery of a busy town costs in maintenance from 200*l*. to 300*l*. per mile per annum. The cost to construct a

reinforced concrete road would be somewhere from 4,000*l.* to 5,000*l.* per mile, and it has been proved that the maintenance of such a road works out under 10*l.* per mile per annum, so that in about sixteen years the road would have paid off its first cost on the saving in maintenance."

"To prove this, I will give you a few instances embracing Australia, United States of America, Canada and this country.

"Part of St. Kilda-road, Melbourne, is a reinforced concrete one. It was constructed about five years ago. The cost of the maintenance on the road has been less than ¼*d.* per square yard per annum. This road has a motor-'bus service over its surface, together with the ordinary town traffic of a main road. Prior to 1915, the County of Outagamie, Wis., U.S.A., had built 60 miles of new macadam roads. During the year 1915 the maintenance of these new roads cost the county 80*l.* per mile, while for 55 miles of reinforced concrete roads during the year of 1918 the approximate maintenance was under 4*l.* per mile, a saving each year of 76*l.* per mile of road, or a total of 4,180*l.*

"The Town County of Islip, on Long Island, New York, in 1917 laid a length of reinforced concrete road across marsh land from 14 in. to 6 ft. deep, of very boggy material. The concrete road was 6 in. at the side and 7 in. in the centre. About 645 ft. by 16 ft. was affected by tidal water and at times covered. Not a single crack or any evidence of settlement showed during the seventeen months the road has been opened to traffic, although large numbers of heavy vehicles, both horse and motor drawn, had passed over it, while tramway cars had been running continuously on the tramway track laid only 2 ft. from the edge of the reinforced concrete road.

"In Canada, the Toronto to Hamilton main road, in 1914, carried over its surface a daily average of 520 vehicles; 262 were private motor cars, three commercial motors, 199 horse-drawn private vehicles and 56 horse-drawn commercial vehicles. At this time the road was a water-bound macadam.

"In 1915 it was converted to a concrete surface road; immediately the traffic increased very considerably. In 1917 it attracted 3,841 vehicles over it daily, of which 3,065 were private motor cars, 107 commercial motor cars, 148 horse-drawn private vehicles and 41 horse-drawn commercial vehicles.

"The maintenance during the two years of this road's existence has been at the rate of less than ¼*d.* per superficial yard, while the maintenance of the previous macadam road had been approximately 3*s.* per superficial yard."

Dealing with other cases of which I have some personal knowledge, and which are also referred to by Mr. Bendall, Mr. S. A. Hill-Willis, surveyor to the Tilbury Urban District Council, in 1916 laid a trial length of reinforced concrete road on a soil of alluvial drift 40 ft. deep before reaching firm ground. It has over it daily more than 250 vehicles, in addition to motor vehicles and tractors, the pre-war census of these being 89 daily. This trial section was laid on the main road leading to the Tilbury Docks, and all traffic in and out of them has to pass over it. A few months ago I had an opportunity of inspecting this road, and the surface appeared to be in perfect condition. On inquiry, I found that the actual maintenance cost since construction had been nil. I should also like to add that when walking from Tilbury Station towards this work, the reinforced concrete portion is noticeable at a distance of at least 200 yards. It seems to stand out conspicuously as a level stretch of road surface and, when compared with the ordinary macadam surface at each end shows, to my mind, the great advantage of concrete.

At the beginning of the war, the Government built a large military camp at Chiseldon and constructed over 2 miles of reinforced concrete road foundation, on which it was intended to impose some type of wearing surface. The military authorities, however, eventually decided to run the traffic directly on the concrete. Nothing has been spent on the road, it has borne very heavy traffic, and it is in good condition to-day, while other roads in the camp have had to be practically remade on several occasions. I saw these roads, while under construction, on two occasions, and was fully convinced that they would give satisfaction.

In Dunfermline, Mr. P. C. Smith, the late surveyor, reconstructed a street with reinforced concrete surface, replacing setts on a clay foundation. The width of this thoroughfare was 15 ft. 6 in., and the length about one-third of a mile. The only expense in maintenance since reconstruction has been about 1*l.* per annum for tar-spraying. The heavy traffic over this thoroughfare consists of the naval base traffic to Rosyth, as well as the ordinary town traffic, together with a motor-'bus service, and on making recent inquiries I was informed that the surface is in really good condition.

With reference to the statements often made by water and gas companies, as well as by contractors and others, that a reinforced concrete road prevents easy access to mains and sewers, and that it causes extra labour to excavate, it is interesting to note the following case quoted by Mr. Bendall:—

"In 1914 a certain gas company brought an action against a certain local authority who had laid down a reinforced concrete road foundation, claiming that by so doing it put them to extra expense getting to their mains. The judge who tried the case ordered a test to be made between plain and reinforced concrete.

"On November 3, 1914, acting on the judge's instructions, Messrs. John Mowlem and Co., Limited, a large firm of London contractors, laid two sections, both being an area of 12 ft. superficial. One was of plain concrete, 12 in. thick, the other was reinforced concrete 6 in. thick.

"The reinforcement was placed about 2 in. from the bottom, and consisted of B.R.C. fabric, having wires of 10 and 5 gauge. The concrete was a mixture of 6 to 1, and when both sections had been completed to nearly the thickness previously mentioned, a ½ in. floating was made with cement mortar. This experiment was to determine the relative time to break holes of the same dimensions through each type of concrete. On May 11, 1915, five men started at 3.10 p.m. on each section to excavate holes, the dimensions being 3 ft. 2 in. by 2 ft. 2 in. Fifty minutes later the hole was completed through the reinforced concrete portion, while the other five men had not finished their work through the 12-in. section unreinforced. The concrete was made with an excellent quality of Thames ballast. The reinforcement in the reinforced section was cut with a cold chisel and did not give any appreciable trouble in breaking it up."

With a view to showing the comparative strengths of reinforced and unreinforced foundations, I have been supplied by the British Reinforced Concrete Engineering Company with the following figures for the "resistance movement" per foot width: Concrete, 6 in. thick, reinforced with No. 9 B.R.C. fabric, 13,000 in.-lb.; the same unreinforced only 4,000 in.-lb. Concrete, 9 in. thick reinforced with No. 9 B.R.C. fabric, 23,000 in.-lb.; the same unreinforced only 10,000 in.-lb. Six inches of reinforced concrete is therefore equal to between 9 in. and 12 in. of concrete unreinforced.

Having said so much, I propose drawing my remarks to a close with a few observations as to the methods which should, in my opinion, be adopted by surveyors who are about to construct reinforced concrete roadways.

1. Whenever it is intended to lay a reinforced concrete carriageway, the engineer or surveyor to the council should give six months' public notice in the press of his intention, so as to give proper y owners on each side of such street an opportunity of having their gas, water, electricity or drainage services examined and, if found faulty, put right.

Further, I strongly advise that whenever such services are examined, no charge should be made to such property owners for street repairs or maintenance from the time they have opened such roadway till such time as the surveyor commences his work. The upkeep and maintenance should be borne by the council, as I believe this does encourage examination and putting in order of the various services. Notice in writing should also be served on the water, gas and electrical engineers of the town.

2. If a new street is to be formed it should be arranged wherever possible that gas, water and electric mains should go down the footpaths, and wherever a pipe, line or electric main crosses the carriageway, they should be laid through stoneware pipes of sufficient diameter to allow (in case of bursts or escapes) of such pipe or cable being drawn from one footway to the other and so save breaking up the carriageways.

3. Drainage of the road bed is vital and should not be neglected and thought of no consequence.

4. The subsoil should be of uniform density and should be thoroughly consolidated.

5. The aggregate used must be clean, hard and tough, and free from foreign matter.

6. The fine aggregate (sand) should be coarse and well graded.

7. A rich mixture must be used.

8. Materials must be accurately proportioned, gauge boxes to suit the proportions should be accurately made, or if the mixings are done by weight then correct methods of weighing should be observed. Too much caution cannot be observed in carrying out this instruction.

9. Mixing must be thorough. If by hand, not less than twice dry and three times wet. If small areas are to be done it would not pay to mix by mechanical means.

10. Sloppy concrete must not be used. This is entirely a matter for the resident engineer or supervisor on the work to determine, as much depends on weather conditions prevailing at the time of laying. (I might add that whenever I start work of this kind I always spend the whole of the first two days on the spot to see that my requirements are properly carried out and that whoever is in charge on my behalf will be fully conversant with them.

11. Reinforcement is necessary, and not only strengthens the concrete but prevents to a very large degree cracking of the concrete.

12. Supervision must be intelligent and thorough. I would also add constant, for I can assure anyone undertaking concrete work of this character that it certainly pays to have a conscientious assistant from the office or a reliable person in charge who will see that every mixing is properly gauged, turned over and laid. My practice is that not a mixing shall be done unless someone in authority and on my behalf is present.

13. Concrete must be prevented from drying rapidly. If this is not done it will be found that the upper surface, owing to either sun or wind, will dry more quickly than the lower portion. It is therefore advisable after the first 24 hours to water the surface of the concrete by means of a fine rose from a watering can as often as it may be thought necessary, the watchman on the work doing this at night. I do not agree with covering the concrete over with wet sand and keeping the same damp.

Up to now I have found that, speaking generally, using a medium setting cement, it usually requires four weeks for the concrete to set before it is ready for traffic to go over the surface.

If the foregoing conditions are observed in the laying of reinforced concrete roadways I am of the firm opinion that we shall have few failures in this country in carrying out our work. Careful observations should be made as to weather conditions whilst the concrete is being laid, and a note taken of any other incidents that may appear to be trivial at the time but which may give us information as to the cause of any failure.

I should like to add that in my opinion a reinforced concrete roadway properly made is to-day the most efficient and economical—it is waterproof, it is the most sanitary road that can be constructed, it is practically dustless in summer and mudless in winter, it reduces scavenging costs to a minimum and is practically non-slippery.

It will be noticed I have not dealt with concrete roads in America, except in so far as I have reproduced extracts from Mr. Bendall's paper. The reason for this is that my only knowledge of these roads is from reports issued by the Americans on the subject, but if all we hear and read about such roads is true, then the engineers and surveyors in America have given this country a good lead in the matter.

We are told by the Government that economy must be our watchword in carrying out our duties. English engineers and surveyors are sadly in want of first-hand information with regard to reinforced concrete roads. I would like therefore to take this opportunity of urging as strongly as I am able that the Ministry of Transport should appoint a few engineers and surveyors and some of the Ministry's officials to visit America and make a thorough investigation of reinforced concrete roads and the methods adopted by American engineers. A report could then be brought up and circulated. Such deputation could make their investigations in, say, six weeks, and I believe the cost of such a visit and report would be infinitesimal as compared with the probable saving to the ratepayers of this country of some millions of pounds in the way of road construction and maintenance.

It may be urged by the Ministry that now is not the time to make these investigations, but with due deference I disagree. Let the investigations be made before the winter and the report be finished, say, not later than February, so that engineers and surveyors preparing their programme for street works for 1920 and 1921 may have some authorised report and advice on which to base their schemes, especially as regards reinforced concrete roads, otherwise we shall still be going very much on the lines of road construction that has been in vogue for years past when only horses and large wheel bicycles used the roads. To-day we must alter. We must face the enormously increasing mechanically-propelled traffic on our roads, and to this end I ask the Ministry to allow a few engineers to investigate the hundreds of miles of reinforced concrete roads which we are told have been successfully laid, and so save us spending money on out-of-date road construction.

I must offer my apologies if I have not made this paper interesting, but time was limited and many things I could have urged in favour of reinforced concrete roads have necessarily been left out. If, however, I can be of service in any way to any of my fellow engineers and surveyors in this country, I shall only be too pleased to give, willingly and ungrudgingly, what advice I can on this question.

In conclusion, I desire to acknowledge gratefully the help I derived in compiling these remarks from the paper written by Mr. Bendall, to which previous reference has been made.

CEMENT CONCRETE PAVEMENTS IN NEW ZEALAND AND THE UNITED STATES AND CANADA.*

By Walter E. Bush, M.Inst.C.E., M.Inst.Mun. & C.E., M.N.Z.Soc.C.E., M.Concrete Institute; City Engineer, Auckland, New Zealand.

In the following paper the writer proposes to outline his personal experience and opinions on the use of Portland cement concrete as a combined foundation and surface pavement for urban traffic streets in the City of Auckland, New Zealand, and to give some notes of his observations on the use of concrete in the same manner for highway purposes in the United States and Dominion of Canada.

In the course of his official duties the writer submitted a report to the City Council, Auckland, upon the streets of the city, dealing, *inter alia*, with the relative merits of various forms of paving, in which he stated his belief in the future of concrete paving for climates like that obtaining in Auckland, especially as motor traction would tend more and more to replace horse traction in the future, and in respect to a number of streets he gave alternative estimates for paving such streets in compressed asphalt, wood block, stone setts and concrete. It was not, however, until the latter end of 1915 that the City Council authorised him to put down the first cement-concrete pavement in the city, although cement-concrete foundations had been put under all paved streets. The measure of success met with in the first street has led to its increasing use, and practically all streets that have since been permanently paved have been carried out in cement concrete, and when the writer left New Zealand in March last, some 35,000 yards in all had been completed, 14,000 yards were in hand, and an additional 135,000 yards had been authorised.

The first street to be paved was Little Queen-street, 423 ft. in length, and lying almost due north and south, so exposing it to the suns rays for the middle part of the day, which means in summer time that the surface temperature is often as high as 120 deg. F., and may sometimes exceed that. Its mean elevation is 9 ft. above sea-level, and it serves the back or cart entrances of a number of warehouses and works to and from which

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traffic is of the heaviest description, both two and three-horse lorries and also motor trucks being used, carrying the largest loads that the very flat grades on the water front make possible, and it is also subjected to much turning and twisting traffic from the fact that many of the warehouses have cart docks, and practically all unloading is done by backing the lorries and trucks either into such cart docks or against the kerb.

The street was prepared for paving by scarifying the water-bound macadam, excavating to the required depth and preparing and rolling the subgrade to the required camber to receive a uniform thickness of 8 in. of pavement, with a fall from the crown to the channel of approximately 1 in 36.

Two-coat work was adopted, the lower 6 in. of 7 to 1 concrete and the upper 2 in. of 3 to 1 concrete. The 7 to 1 concrete consisted of 5 parts of clean beach shingle having a fair proportion of sand, two parts of broken basalt between 1 in. and 2½-in. gauge, and 1 part of Portland cement (New Zealand manufacture), while the 3 to 1 concrete consisted of 2·25 parts of beach shingle, 0·75 parts of ½-in. gauge basalt chippings and 1 part of cement. The top 2 in. was laid immediately after the lower 6 in. had been roughly brought to its proper shape, and while it was quite green, so as to ensure that the whole 8 in. was practically homogeneous.

The surface was brought to a proper camber by a straight timber template shod with steel, operated transversely to the longitudinal axis of the street, from the centre to the channel, on screeds of angle iron fixed to bars in the ground, after which it was steel trowelled till it presented a wet even surface; after setting had commenced it was lightly broomed to remove glazing of any portion of the surface, and when setting had taken place the surface was covered with bags and kept wet for eight or nine days.

It being midsummer, only three weeks was allowed before the paving was opened to traffic. It was then allowed to carry the traffic for nine months, before being treated with Californian asphalt, brushed on hot and dressed with screened beach shingle.

Prior to the application of the asphalt dressing the surface showed slight signs of wear in one or two places where the quality of the shingle had not been so good as in the remaining portions, a fact which emphasises the necessity of only using the best qualities of aggregate available in this class of pavement.

The next street (Durham-street) was done with one-coat work 7 in. thick of 5 to 1 concrete, the traffic conditions not being so severe as in the first-mentioned, and it was left untreated and has stood quite satisfactorily since its completion in October, 1916.

The third street to be paved in concrete (Park-road) forms a portion of Auckland's busiest traffic outlet, and lies immediately eastward of the important reinforced concrete viaduct known as Grafton Bridge, which is surfaced with compressed Neuchatel asphalt.

It carries mixed traffic, most of which is fast travelling, and including heavy petrol motor wagons and char-a-bancs, but no motor 'buses similar to those so common in London, the number of vehicles counted being over 2,000 per day of 10 hours.

The work was done in two halves to prevent stoppage of the traffic, and was much delayed by difficulty in obtaining shingle owing to bad weather, and this resulted in some shingle being used which was not absolutely first-class and also in the street being opened up for traffic sooner than was advisable, and it caused the writer to cease using shingle for aggregate and to substitute therefor broken basalt and sharp sand, as he came to the conclusion that the desire of the inspector and foreman on the job to get on with the work might prejudice their judgment in deciding as to the suitability of shingle brought on to the job, while with the basalt and sand he could practically ensure the obtaining of a standard of quality.

The alteration was made during the progress of the Park-road job, which was a one-coat pavement of 5 to 1 concrete, 8 in. thick, and the bays done with the basalt and sand aggregate showed enough superiority to the rest of the work to justify his conclusion and he has since found no reason to modify it.

With the exception of a short length of the basalt and sand concrete, the whole surface was treated with a dressing similar to that used on Little Queen-street.

The accompanying schedule shows the work done to date:—

Name of Street.	Length in Feet.	Area in Square Yards.	Thickness in Inches.	Cost per Square Yard, Pavement only.	Date of Completion.	Remarks.
				s. d.		
Little Queen-street ..	423	2,187	8	10 0	Feb., 1916 ..	See paper.
Durham-street ..	212	390	7	9 0	Oct., 1916 ..	See paper.
Park-road	650	2,984	8	9 0	July, 1917 ..	See paper.
Market roads	640	1,340	7	8 0	March, 1918 ..	Untreated.
Exchange-lane ..	140	155	4½	5 3	Dec., 1917 ..	Untreated.
Quay-street Extension	530	3,828	8	9 0	March, 1918 ..	Untreated. Intersected by railway sidings.
King's Wharf-road ..	605	2,351	8	9 0	May, 1918.. ..	Untreated. Intersected by railway sidings.
Beach road	1,896	12,801	8	—	May, 1919 ..	Double track tramway.
Anzac avenue ..	2,347	9,909	8	—	—	Under construction in March, 1919.
Symonds street ..	3,100	13,427	8	—	Sept., 1919 ..	Double track tramway.

Total length, 10,543 ft. Total area, 49,372 square yards.

In addition to the above an area of over 2,000 sq. yards in Pitt-street, on which trial lengths of proprietary bituminous pavement had been laid on a 6 in. concrete foundation and had failed, was surfaced on the old concrete foundation with a rich concrete (3 to 1), half of the area being an average thickness of 3 in. and the remainder 3½ in. This was only completed in March last.

Note.—The prices paid for labour and materials were as follows: Labourers 10*s.* 7*d.*, finishers and machine men 11*s.* 7*d.* per day of 8 hours; cement delivered 50*s.* per ton; basalt chips and screenings 10*s.* 3*d.*, basalt road metal, 2½ in. gauge, 9*s.* 3*d.*, and sand 10*s.* 11*d.* per cubic yard.

In all the streets paved since 1917, the paving has been one-coat work of concrete, composed of clean basalt chippings and screenings varying from 1¼ in. gauge to "fines" mixed with 25 per cent. of sharp beach sand free from shell and gauged with Portland cement in the proportion of 5 of aggregate to 1 of cement, but prior to the concrete being laid the sub-grade is sprinkled with 2¼ in. clean basalt road metal as a measure of economy. In all cases the sub-grade is carefully prepared and rolled solid, and steel rod reinforcement is laid transversely over trenches likely to cause trouble by subsidence.

The concrete is mixed by machine, one gang using a "Eureka" continuous self-mixing type and the other a 7 cub. ft. "Koehring" batch mixer fitted with boom distributing hopper. Both machines have given fair results, but neither is ideal, the writer preferring a "batch" to a "continuous" mixer, and in the case of the batch mixer one of larger capacity; but he had to take what was available at the time.

On the question of hand *versus* machine mixing he has a decided preference for the latter, and is surprised that so few are being used for concrete work in street foundations in this country. In America their use is universal, and on both counts of economy and efficiency he would strongly advise their adoption.

Dealing with the much-discussed question of joints, the writer has adopted the use of tarred paper, folded to form two thicknesses, and these are placed approximately 56 ft. apart, the length of bay being laid 14 ft., and four bays a convenient length for a joint.

Out of 35,000 yards laid, of which only 5,216 had been coated, not a single crack had been discovered between the bays, and only in Little Queen-street and Park-road, in which shingle concrete was used, were there any noticeable signs of wear. The tarred paper joints and those formed by the junction of two bays are coated with asphalt and fine shingle.

In America cracks are often seen in concrete roads, but most engineers there do not attach any importance to them, but treat them with some sort of asphaltic filler.

Where concrete paving is laid in streets with tramway tracks, a longitudinal wall, 9 in. wide and as deep as the bottom of the tram track foundation, is put under the pavement 18 in. from the outer rail, to prevent disturbance of the pavement when the track, mostly laid on sleepers, is being packed or repaired. A stone sett margin is used to separate the pavement from the portion of road occupied by the tram track, which is surfaced with bituminous macadam, 2 in. thick, laid on water-bound macadam in the margins and between rails and well rolled.

The cross fall adopted is 1 in 36, unless special conditions necessitate a variation.

The method of finishing adopted has been similar to that used in the case of Little Queen-street, but now a belt is being used with good results.

Arising from his experience in carrying out concrete paving the writer desires to emphasise the adoption of the following precautions:—

(*a*) The thorough preparation of the sub-grade or foundation, including the use of a suitable steel reinforcement over trenches or holes where subsidence may take place.

(*b*) The use of the very best quality and uniformity of aggregate and cement, and their thorough mixing, with as small a quantity of water as is necessary to ensure density of mass and smooth finish.

(*c*) The utmost care in the tamping, screeding and trowelling of the pavement.

(*d*) The keeping damp of the concrete during the process of setting and hardening.

(*e*) The allowance of ample time for setting—never less than three weeks in summer and four in winter or damp or cold weather, and preferably longer, before traffic is allowed to use the pavement.

In regard to concrete roads in America and Canada the writer has recently spent 3½ months touring the United States and Canada in order to obtain information on municipal works and administration, and one of the subjects particularly studied was that of street pavements and road making generally. He left New Zealand in March last and travelled via Suva and Honolulu to Vancouver, B.C., and thence to Victoria, B.C., Seattle-Portland, Oregon, San Francisco and the Bay Cities-Los Angeles, San Diego, Salt Lake City, Kansas City-Chicago, Milwaukee, Niagara Falls, Buffalo, Toronto, Detroit, Washington, Wilmington and the State of Delaware, Philadelphia, New York, Fall River, Boston, Montreal, Ottawa and Quebec, covering some 9,000 miles by rail and 3,000 by motor car, which enabled him to see various forms of pavement and gain considerable information on the question of concrete roads.

Generally it may be stated that concrete has not been largely used as a pavement for heavy traffic streets in large cities, but it has and is being used extensively for residential streets in cities and for paving highways leading out of and connecting cities together, and those engineers who have laid or are laying it seem convinced of its value and suitability, even for the extreme conditions of temperature and weather that are experienced in America and Canada.

The writer found excellent methods of organisation in connection with the carrying out of work by contract and direct labour, and also the utmost care being taken to secure good results, although none of the concrete pavements inspected showed any marked superiority to those recently laid in Auckland.

In the earlier executed pavements seen it was evident that, as in all pioneer work, the success achieved was only moderate. It would, however, be a grave mistake to judge concrete pavements by such early examples, and at the present time nothing is being left to chance in the securing of the best results, and the writer left America and Canada deeply impressed by the scientific attitude and tremendous keenness of American and Canadian engineers and contractors, to whom he was indebted for the opportunities of viewing their work.

Amongst the earlier types of concrete pavement, the writer saw some good examples of "Hassam" at Vancouver and New Westminster, B.C., and the road between these cities, some portions being laid on steep grades of 1 in 10. The Hassam pavement, as most road engineers are probably aware, is laid by spreading a rich cement mortar and embedding therein hard cubical road metal, forming virtually a cement concrete macadam. It has a moderately good appearance, gives fair foothold to horses, but is not so smooth for other vehicular traffic as the mixed concrete pavement.

It seems to have had a considerable vogue in the past, but the writer did not find that any large areas were now being paved with it, and that is no doubt accounted for by the fact that patent pavements are often barred by municipal ordinance and that it is more expensive to lay than the other types.

Another form was the pavement laid in the ordinary way but grooved with steel tods to give foothold and probably to imitate the grooved brick pavements. Personally, the writer did not care for it and could not recommend it, except possibly for very steep streets.

The first concrete road in process of construction the writer saw was at Seattle, Washington, where Leary-avenue, a thoroughfare forming one of the main roads leading out of the city, was being paved on one side of the tramway track with concrete. The strip was 18 ft. wide and 8 in. thick, and the proportions used 1 of cement, 2 of sand, and 3½ of gravel, the latter consisting of all grades of material from 3 in. to ¼ in. gauge, and the sand from ¼ in. down.

The work was being done by contract at a price of $2·63 (10*s.* 11½*d.*) per square yard, exclusive of kerbing and sub-grading but inclusive of heavy temporary timber ribbons or kerbs. The mixing was by machine, a 16 cub. ft. Koehring self-propelled gasoline driven mixer being used; it was tamped by a heavy wooden template operated parallel to the longitudinal axis of the street, then trowelled with wooden floats 3 ft. long, and finished with a roller 4 ft. long and 8 in. in diameter, weighing approximately 70 lb. It was kept sprinkled for 30 days and closed for 60 days. The rate of progress per full working day was 300 lineal ft., or 600 sq. yards, the concrete gang consisting of 23 men and foreman, two inspectors being also employed.

Labourers were paid $4·50 (18*s.* 9*d.*) per day, concreters $5·00 (20*s.* 10*d.*), finishers $5·50 (22*s.* 11*d.*), sand and gravel cost $1·75 (7*s.* 3½*d.*) per cubic yard at pit, and cement $2·70 (11*s.* 3*d.*) per barrel of 384 lb., or 65*s.* 7*d.* per ton.

It may be interesting to note that Seattle had 9·19 miles of concrete streets out of a total of 285 miles more or less permanently paved, and the City Engineer (Mr. Dimock) was not prepared to express any definite opinion on the merits of concrete paving for city streets, but stated he could recommend brick pavements, and especially the monolithic type, that is to say, laid directly on concrete without a sand cushion and flushed with cement mortar grout, and for residential streets on flat grades bituminous pavements.

The county authorities, on the other hand, greatly favoured concrete pavement for main highways, and at the end of 1918 had laid 36·65 miles out of a total of 108·26 miles of paved, bituminous or macadamised streets in King County, and had started on large extensions in April. There the mix was 1 cement, 2 sand and 3 gravel, and the cost in place for a pavement 6 in. thick at sides and 7 in. at the crown was $2·25 (9*s.* 4½*d.*) per square yard. The first concrete pavements were laid in 1914, of a length of 6·35 miles, and were satisfactorily carrying county traffic of all descriptions.

The concrete pavements in Portland, Oregon, San Francisco and other Bay cities, Los Angeles and San Diego, do not call for special mention, but on the other hand the work of the Californian Highway Commission is of very considerable interest. This Commission commenced operations in the summer of 1912, and up to June, 1918, had built or surfaced nearly 1,100 miles of highway and had taken over 160 miles of surfaced high-

ways built by counties, all of which latter was either oiled or bituminous macadam, and of the amount actually surfaced, 1,008 miles were of cement concrete, 528 miles being protected with a thin (⅛ in. or ¼ in.) bituminous top and 480 miles not so protected.

The protected type of concrete pavement may be called the "Standard" of the Commission. It consists of a base generally 15 ft. in width and of a minimum thickness of 4 in., but these dimensions were being exceeded when the writer was in California.

The mix used is 1 of cement, 2 of fine and 4 of course aggregate, and the aggregates used are sand, gravel and crushed rock, varying with the locality. The mixing is done by machine, enough water being used to produce a jelly-like consistency. It is tamped with heavy crown grade templates shaped to fit the camber of the road, which are worked along 4 in. by 2 in. longitudinal ribbons or kerbs, it is then cross rolled with a 10 in. diameter roller, 5 ft. in length, and smoothed with a thin wooden slab operated from the side of the road. Steel reinforcement is used where special sub-grade conditions make it necessary.

The practice of placing some elastic filler between joints was not being followed, although it had been customary to make them at the end of every day's or half-day's run, say every 300 ft. or 150 ft.

The concrete is "cured" by sprinkling during the first 24 hours and then by forming ponds of water, over the surface for another ten days, and it is protected from the traffic for one month after laying.

The thin bituminous wearing surface is formed by applying road oil, containing approximately 90 per cent. of 80 deg. penetration asphalt, heated to a temperature of 250 deg. Fahr. to 500 deg. Fahr. through a pressure distributor at the rate of one fourth of a gallon (U.S.A.) per square yard, and immediately covering this with a layer of mineral aggregate either crushed rock screenings or fine gravel of a maximum diameter of ½ in. and a minimum diameter of about ¼ in. This is followed by a second application of oil and screenings at a short interval and then the traffic is allowed to effect the necessary forcing of the screenings into the oil. A light rolling is considered an advantage but not a necessity.

The writer travelled over many miles of this pavement and also over unprotected concrete. The former had generally the better appearance, although the plain concrete gets covered with a thin film of oil droppings from the thousands of motors* passing over it which renders its surface very dark.

Mr. A. B. Fletcher, Highways Engineer, in his first biennial report dated December, 1918, says, "The oldest thin bituminous surfacing laid by the Californian Highway Commission has been under traffic for more than five years on the main San Joaquin Valley Highway just north of Fresno. This surfacing has in this length of time required little attention, and to-day, while it shows its age, it still has a year or two more of useful life."

Detroit and Wayne County, Michigan, provide interesting comparisons. The former has brought sheet asphalt pavements on concrete foundations to a high standard and is steadily concentrating on that type of pavement, while Wayne County, of which Detroit is the population centre, claims to be the pioneer in concrete highway construction and is steadily pursuing the policy of building concrete roads to-day. It started over 10 years ago and to-day has 170 miles, and the writer can testify to the excellent condition of many of the roads, in spite of the heavy traffic to which they are subjected. He travelled over a section of Grand River-road which was widened in June, 1916, from 16 ft. to 20 ft. and resurfaced with 3 in. of reinforced concrete, and found that the "experiment" as the Board of County Road Commissioners called it, had been successful, and also that the more recently constructed roads gave exceptionally smooth running, even at speeds of 50 m.p.h.

The particular features of the Wayne County roads are the increased thickness of concrete, 7 in. at the channel and 9½ in. at the crown, the adoption of two course or better put "two mix" construction in place of one course, the use of belts for finishing the surface of the concrete, and the placing of transverse joints ½ in. in thickness every 25 ft. apart, filled with tar composition filler.

The first is rendered necessary by the heavy loads the pavements have to carry, the second to secure the use of richer mix and of a very hard stone for the aggregate in the wearing surface, which is made 3 in. thick, the third is carried out by working a canvas belt 12 in. wide with a crosswise movement while slowly moving forward, and following this up with another belt 8 in. wide and kept at an angle of 75 deg. with the line of pavement and worked in a similar manner to the first, and the fourth is done because the Commissioners, while deeming the elimination of joints desirable, do not think that it would prove successful.

In the city of Milwaukee there is barely a mile of concrete paving, but in the county there are some excellent concrete roads, the length being stated as 125 miles. The writer saw two jobs in course of construction, the average thickness of paving being 7½ in., and the width 16 ft., and the work one course with joints filled with tar composition.

On one of the jobs 16 men, 1 foreman and an inspector were employed, and a 16 cub. ft. Koehring self-propelled mixer, and the rate of progress was 250 ft. per day, and the contract price $1·88 (7*s.* 10*d.*) per square yard.

In the State of Virginia the writer was shown by the courtesy of the Engineers of the Federal Government Bureau of Public Roads a concrete road constructed to Fort Humphreys, some 20 miles from Washington. This stretch of road proved interesting because complaints had been received of buckling taking place and the visit was to investigate these. Generally the road was found to be in good condition but buckling had taken place at a few of the joints, resulting in fracture of the concrete in some instances, and it offered evidence of the movement that takes place through expansion and contraction of concrete slabs in a climate where there is a great range of temperature. The writer had experienced this movement in other concrete structures he had designed and constructed, but not in concrete paving.

Delaware State Highway Commission is putting down extensive areas of concrete roads under Mr. C. H. Upham, Chief Engineer.

Through the public spirit of Mr. Dupont and at his sole expense, a concrete roadway is being put down from end to end of the State near the river Delaware, while further inland the State Commission has planned and is now carrying out from the public funds a concrete highway which will ultimately stretch practically from one end of the State to the other.

In this latter work the width adopted is 16 ft., the thickness 8 in. in the crown and 6 in. at the sides, giving 2 in. camber on a flat subgrade. The side forms used are of stamped steel in the shape of a channel 6 in. deep 2 in. wide with a return of ¼ in. The mix consists of 1 cement, 2 sand, 4 stone and incorporated in the cement is 10 per cent. by volume of hydrated lime, which is added for its hygroscopic properties, the theory being, that by improving the workability of mortar and concrete, it reduces the free water necessary in direct proportion to the amount present in the mixture and further retains water for the later hydration of the cement, releasing this water slowly and off-setting the loss of evaporation or drying out.

The method of finishing the surface of the concrete is by the use of a heavy steel channel template 10 in. deep, weighing 400 lb., followed by a roller 11 in. in diameter and 6 ft. long weighing 100 lb., and then by a 10 in. bow belt, or belt to which tension has been imparted by a timber or steel bow.

Sun covers are used to protect it from the sun's rays for the first day and then it is covered with earth and kept moist for another 14 days. The writer paid particular attention to the organisation on two separate contracts. In both about 300 ft. of 16 ft. roadway was being done per day of 10 hours.

In one the staff consisted of 27 men, exclusive of 8 men, ganger and boy setting side forms and shaping subgrade, while the plant comprised a 10-ton steam roller, a Koehring material conveyor and loader and 18 cub. ft. self-propelled batch mixer.

In the other the mixing of the material was done at the nearest railway depôt, loaded into boxes 3 ft. 9 in. long, by 3 ft. 6 in. deep, by 3 ft. wide, having hinged doors and sloping bottoms, placed two to a truck and conveyed on a Koppel 2 ft. gauge in lustrial railway to the job, where the boxes were lifted by a pivot crane, attached to the mixer, and discharged into the mixing drum, which had a capacity equal to that of one box, viz., 24 cub. ft. Seventeen men were employed on the concreting, 8 men and a ganger on subgrading, 4 men on the railway track, 3 locomotive drivers, and 6 men on the railway depôt, and the plant in addition to a Foote steam-driven mixer, included 3 Plymont gas engine locomotives, 1 stiff-legged derrick and ¼ yard steam clam shell bucket hoist.

Good work was being done on each job, and there, as elsewhere, great confidence was expressed in concrete for pavements, although an important highway between Wilmington and Philadelphia was being paved with brick pavement on a concrete foundation for the State Highway Department.

The above notes, while they do not exhaust the subject from the writer's standpoint, give a very fair idea of American practice in connection with concrete pavements, which are being developed at a tremendous rate. In April last it was estimated that there were approximately 113,600,000 sq. yards of pavement in the country or 10,755 miles of a width of 18 ft., and everywhere these are being added to enormously during the present year.

In summing up the writer expresses the hope that he has advanced sufficient evidence to justify all those interested in the improvement of city, urban, and rural streets, in giving concrete a very important place in their consideration, when selecting a material for the surfacing of roads carrying continuous and heavy traffic.

Other things being equal, price will always be a determining factor, and in this connection concrete must be a powerful competitor with other forms of pavement.

The objections urged to its use, such as the long period required for setting and consequent diversion of traffic and the difficulty of effecting repairs, can be overcome if intelligently approached, and the advantages it possesses are so obvious, that it can safely be predicted that it has come to stay as an important factor in providing those facilities for traffic which the recent application of mechanically propelled traction have rendered absolutely necessary.

At the same time the writer would emphasise the necessity of definite limits being placed on the character of and the axle loads carried by mechanically operated or horse drawn wagons, for it is futile to imagine that a highway can carry excessive axle loads and undergo destructive treatment from unsuitable tyres, with impunity. As in all other engineering construction, the load should be defined and the work to be performed specified before a pavement can be adequately designed to meet the stresses of future traffic, and in the interests of all road users and of the public who find the money to make and maintain such roads, excessive loads, high speeds and unsuitable tyres should be prohibited, and a proper standard agreed upon and adhered to.

In conclusion the writer has to thank the Committee of the County Councils Association for the opportunity of presenting this paper, and to express his obligation to those who in the United States and Canada have facilitated the obtaining of information on the subject dealt with.

* Only those who have seen this motor car traffic can form an idea of its intensity, for California registered in 1918, 407,761 motor cars or 1 to every 7 of its population or 6·6 miles of its public rural roads, and in the neighbourhood of the large cities and towns there is a long procession of motor cars on the highways, more especially at week-ends.

ASPHALTIC MACADAM (BITUMINOUS) ROADS, AND THEIR EXTENDED USE.

By H. T. Wakelam, M.Inst.C.E., F.G.S., County Engineer for Middlesex.

The writer desires it to be understood, at the outset, that the term "asphaltic macadam," which forms the subject-matter of this paper, implies that the material covered by the term consists either of (1) pure asphalt, (2) native bitumen, or (3) material obtained artificially from asphaltic mineral oils, and used for the wearing surfaces of roadways. (Pitch and tar compounds are entirely outside the questions, and materials, referred to in the following remarks.)

With this introduction the writer would state that before the advent of the motor omnibus, and other heavy mechanically-propelled vehicles, asphalt paving, in this country was, practically, confined to the use of compressed natural rock asphalt, laid on foundations of Portland cement-concrete, in a manner similar to that adopted in Continental countries such as France, Italy and Germany, whence mineral rock asphalt is imported to the United Kingdom. Rock asphalt laid on concrete, in the form of a "mastic" was also to some extent employed, and spasmodic experiments proceeded, from time to time, on the lines of the American practice, with "synthetic" asphalt, which is produced by a mechanical incorporation of natural bitumen (such as that obtained from Lake Trinidad) with aggregates of sand and broken granite.

The above briefly sets out the position of the asphaltic paving industry in this country until the important development of mechanically-propelled traffic, which development necessitated a rapid change in the systems of road construction, and maintenance, commonly practised up to that time. The demands brought about by this traffic, for smooth and dustless roads, led to experiments of many kinds being carried out with different surfacing materials, and many of the best known engineers of Great Britain quickly endeavoured to meet the pressing necessity for the radical changes required in road administration. The said changes became imperatively necessary, to meet the quickly-growing needs which presented themselves, as the consequential result of the activities and inventive genius of the motor engineer, and the new kind of traffic which followed in his train. Progress, after many trials to secure a suitable surface to meet the said traffic changes, has been most marked, and the writer believes it is now generally acknowledged that one of the best solutions of the difficulty, in finding a suitable road surfacing material, to meet the exigencies of mechanical road transport, has been obtained by the use of "asphaltic macadam."

The experience of the writer of the virtues and wearing qualities of this material, leads him to think that, for roads on which the traffic necessitates a good hard material, of an impervious nature, and sufficient to withstand, to an eminent degree, the wear and stress of a continuous user of motor omnibuses, with other heavy traffic, one of the best things is "asphaltic macadam" laid *in situ*. This material, judging from results already obtained, will give a life of ten or twelve years under heavy traffic conditions.

Natural mineral rock asphalt, laid to a thickness of not less than 2 in., on a 9-in. Portland cement-concrete (reinforced) bed, is, admittedly the most durable form of asphalt paving, but as the initial cost of this form of construction is high, and especially so under existing prices of labour and materials, it is practically impossible to use it on all roads, and local conditions in many cases would not warrant its adoption.

The term "asphalt" in this paper covers only the natural rock which is imported to this country from mines at Seyssell, Gard, Lovagny, Mons, Haute Savoie, Val de Travers, Neufchatel, Lucerne and Vor Wohles. There are also natural mineral rock asphalts in Spain, Greece and Russia. The chief constituents of the material are bitumen, calcium carbonate, magnesium carbonate, sand and sulphur.

Its use for roadwork is traceable, in Continental and other countries, to the seventeenth century. Asphalt mines are worked practically on the lines of ordinary quarrying carried out in this country.

In contradistinction "asphaltic macadam" is usually an artificial composition of native bitumen, sand (aggregates) and cement. The bitumen used in its production is chiefly obtained from the Isle of Tinidad. There are two sources of supply, namely, the Lake of Trinidad, and the land area, of very many acres, which has been covered by overflows from the lake. The material is supposed to be a resultant deposit, caused by volcanic effects, of which there is an estimated minimum of some 9,000,000 tons available.

Rock asphalt is a mineral pure and simple, and used in its almost natural state; whilst "asphaltic macadam," as will be gathered from the above, is obtained by an admixture of different materials, and does not possess

* Paper read before the County Councils Association, at the Roads and Transport Congress, Friday, November 21, 1919.

the same wear-resisting qualities, or the length of life, under traffic and climatic conditions, as those obtained from natural "asphalt."

Consideration of the monetary aspect, which is such an important factor in producing roads with surfaces sufficiently smooth and hard-wearing to resist, in particular, the impact and stress of motor omnibuses, led the writer to look around to see if there was a proprietary article, which would answer the requirements of mechanically-propelled vehicles, at a cost commensurate with the life of the material, and which would be suitable for road users.

As far back as 1906, the writer submitted a paper, on "Tar Painting of Metalled Road Surfaces," for discussion at the annual meeting of the Institution of Municipal and County Engineers, held in London, and gave therein the results of his experiments, in this connection, which had extended over three or four years previously to that date. The writer was one of the first, if not the first, to tar-paint road surfaces in this country, and since 1906, when his remarks, on the value of tar-painting for road surfaces, were somewhat sceptically received, it has come into general use, and is now recognised as a valuable factor in connection with the upkeep of roads.

It has been found, however, that metalled surfaces, even when annually tar-painted, are not sufficiently strong to resist the wear and tear of mechanically-propelled vehicles. Metalled roads, tar-painted each year, have much in their favour and, especially so, where the traffic is light, and railway facilities are difficult in sparsely-populated areas. In many districts, however, this material does not fulfil the requirements of present-day traffic, and, owing to this, the writer was led, with many others, to experiment with different kinds of materials to secure, if possible, at a reasonable cost, something of an artificial nature which would prove equal to the exiguous requirements of the rapidly-developing mechanical traffic.

To this end experiments were carried out by the writer in the spring of 1907, on one of the most important main roads leading out of London, when selected (continuous) sections of the road, of equal lengths, were resurfaced with the following materials, viz. :—

1. Tarmac.
2. Tarred Clee Hill granite—2-in. gauge, mixed with 1 in. to ¼ in. tarred limestone—consolidated to a depth of 4 in. and tar-painted.
3. Tarred limestone—2 in. to 1 in. material—consolidated to a thickness of 4 in. and tar-painted.
4. Tarred flints, 2½ in. gauge, with 1 in. to ⅝ in. tarred limestone and tar-painted.

The materials laid on Sections 3 and 4 had a comparatively short life, and were quite unsatisfactory for heavy traffic, whilst Sections 1 and 2 gave better results, but in their turn they were removed and "asphaltic macadam" laid in their place. The latter has proved satisfactory, both from a point of resultant wear and tear, and from the fact that there has been a saving of 227*l.* per annum in the expenditures on scavenging and watering since the asphaltic material was laid on the road. This, with other obvious advantages, points to the conclusion that a large extension of asphaltic work, under certain traffic conditions, may well be looked for. The said materials are impervious, and withstand, to a great degree, the impact and stress of motor omnibus traffic. There are no traces of the effect of the "suction" set up by the use of "twin" rubber tyres, which tends so much to the destruction of ordinary metalled road surfaces by omnibuses, and other mechanically-propelled vehicles.

Asphaltic materials are easily cleansed, and there is no absorption of animal urine, or open joints, or interstices, in which excrementitious matter may accumulate and decompose, to get blown about to the detriment of the public health.

As stated above the materials experimented with were removed, and a length of about 5 miles of road surface was covered with asphaltic macadam in about 11 weeks.

The work was carried out by two well-known firms, who guaranteed it for a period of ten years. The initial (pre-war) cost was 8*s.* per square yard, plus a maintenance charge of 2*s.* 3*d.* spread over the ten years period.

The analysis of the surfacing work carried out (on a Mendip limestone base) was as follows :—

	Per Cent.
Bitumen (soluble) $C.S._2$	11·50
Passing 200 mesh	16·30
Passing 100 mesh	13·40
Passing 80 mesh	7·50
Passing 50 mesh	38·90
Passing 40 mesh	4·00
Passing 30 mesh	2·70
Passing 20 mesh	2·30
Passing 10 mesh	2·40
Retained 10 mesh	1·00
	100·00

The base on which the surfacing work was laid consisted of a bed of graded Mendip limestone, mixed with bituminous material, covered with asphaltic macadam, as a wearing coat, to a finished thickness of 1½ in., the old road surface being properly prepared to receive it. The contracts were carried out in June, July and August, 1913. Since that time very little money indeed has been expended on the road in the way of repair, and, judging from appearances, the life of the work will be well over the ten years' guaranteed maintenance period.

The following specification by the writer formed the basis on which the contracts were let :—

1. The contractor shall lightly scarify the existing road surface and reform, steam roll, and consolidate the same to the contour required for the new surfacing. He shall also provide where required in this connection, new Clee Hill granite metalling to form a good sound surface for the reception of the asphaltic materials. The best of the old metalling excavated shall be well screened, and if considered suitable, used for filling up purposes. All surplus materials not required, and approved by the engineer for re-use, shall be carted away by, and at the expense of, the contractor, who shall provide the necessary tips for the same.

2. Instructions to proceed with the work will be given as early as possible after the date of the acceptance of the tender by the County Council, but the contractor shall take into consideration any deterioration of the old road surface which may take place during the time which may elapse between the date of the said acceptance of tender and the completion of his contract, and shall carry out at his own cost all necessary repairs to the length of road covered by his contract that may be required during the period.

3. The contractor shall provide and lay, on the prepared surface, a bituminous pavement, consolidated to a depth of 4½ in., in two layers, in the following manner.

4. The bottom layer shall be composed of broken Mendip, or other approved limestone, varying from ¾ in. to 1½ in. in size, with the addition of suitable filling, cemented together with Trinidad Lake bituminous composition.

5. The top layer shall be composed of silica of fine grade, Portland cement, and refined Trinidad Lake bitumen, as a cementing agent, all to approval.

6. The materials comprising the surfacing shall be heated separately, after being weighed in definite quantities, and incorporated in a batch mixer, with the cementing agent.

7. The resulting composition shall be delivered to the road in a hot condition, and laid to a contour not exceeding 1 in 36 to 1 in 40, to the specified thickness, and shall be compressed by suitable rollers. Cross-rolling, by a heavy hand roller, shall be carried out at the discretion of the engineer.

8. The contractor will be required to maintain the whole of the bituminous surface for a period of ten years from the date of completion, and the remaining contingent work comprised in the contract for a period of twelve calendar months.

9. Any side, or cross roads, interfered with, shall be excavated, reformed and graded, to accord with the levels of the new work along the main road, and shall be finished off with suitable materials.

10. The contractor shall provide for contingencies a sum equal to 5 per cent. of the amount of his tender, such sum to be expended as the engineer may direct. Any portion of the amount remaining unspent, at the completion of the works, will be deducted from the contract when the final statement is prepared.

In 1914, another important main road leading out of London was similarly dealt with. Both capital and maintenance costs, per square yard, were exactly similar to the figures above quoted.

The company who carried out, and are maintaining, the work, have had no expense, to date, in connection with it, although the road during the war period was (and still is) subjected, both day and night, to an exceedingly heavy motor lorry traffic.

The surfaces of the two roads treated are smooth and hard, and bar the inevitable waviness and corrugation, which is inherent to all kinds of roads under motor traction, the carriageways are in an exceedingly good state—with one excepted short length. The latter is a section about 80 yards to 100 yards long upon which the asphaltic macadam was laid, as an experiment, on a 6 to 1 Portland cement-concrete bed, 6 in. thick. The writer was of the opinion, at the time, that asphaltic macadam, spread to a thickness of an inch only, on a hard rigid foundation (to which there could be no practical cohesion) would be bound to corrugate quickly and "roll up." The result has fulfilled his expectations! More money has since been expended on the short experimental length, referred to, than on the remaining length of the road, and it has recently been decided to remove the concrete and, in its place, to substitute a resilient bed of limestone, mixed with a bituminous material, and coated with asphaltic macadam, to accord with the remainder of the road.

With regard to the question of "waviness and corrugation" above referred to, much has been said, and written, from time to time on this important point, and many suggestions, of a theoretical kind, have been offered, and have been stated to be both a remedial and preventive measure, in regard to the trouble experienced in this connection. It has been suggested that corrugation is due (1) to bad steam rolling; (2) to faulty spreading of materials; (3) to the use of poor quality binding materials; (4) to inter-attrition; and (5) to the variations in the qualities of the materials used. The ordinary man in the street would, perhaps, accept any of these as the cause of corrugation, but to practical men, who are daily studying road questions, a solution of the matter is looked for in other directions. Previous to the advent of mechanical traction, as we know it to-day, roads were steam rolled, the same materials were employed, and their qualities were just as variable as they are now, but corrugations as now seen and experienced, were practically unknown! Corrugations cannot, therefore, with impunity, be attributed to any of the above-named causes. To the mind of the writer the chief cause of corrugation is vibration combined with friction!

Since the contracts above referred to were carried out, the writer has carried out other road contracts of considerable magnitude, totalling many thousands of pounds, in connection with which asphaltic materials have formed the surfacings. In two or three of these contracts, selected clinker from a refuse destructor formed the bottom beds in place of limestone.

The wearing coats laid on the clinker were composed of natural bitumen, sand and cement, as follows :—

	Per Cent.
Bitumen (soluble) $C.S._2$	11·50
Passing 200 mesh	16·30
Passing 100 mesh	13·40
Passing 80 mesh	7·50
Passing 50 mesh	38·90
Passing 40 mesh	4·00
Passing 30 mesh	2·70
Passing 20 mesh	2·30
Passing 10 mesh	2·40
Retained 10 mesh	1·00
	100·00

The writer has also experimented with a length of asphaltic macadam laid in one coat, on an old granite macadam surface. This experiment is being carefully watched, and notes taken with regard to it.

For the purpose of the experiment, the old metalled road surface was lightly scarified, and adjusted to proper levels, and thoroughly steam-rolled to provide for a single coating of refuse clinker asphaltic macadam, which was prepared in the neighbourhood of the road on which the material was laid.

The formula of the proceeding was as follows :—

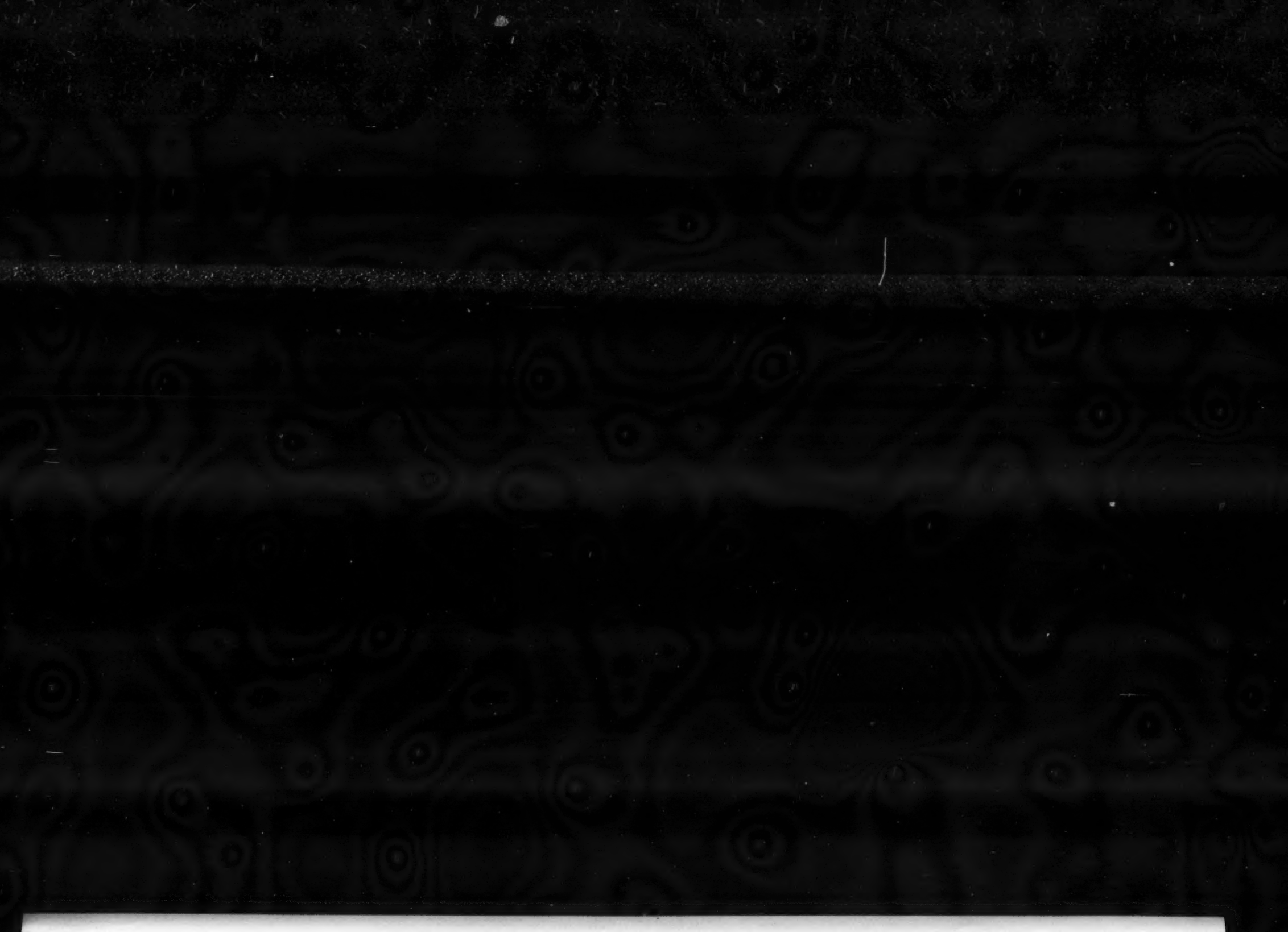
7·3 cub. ft. of fine clinker refuse residual about 482 lb. in weight.
68 lb. of Portland cement.
65 lb. of ½-in. Clee Hill granite chippings.
65 lb. of fine clinker retained on ½-in. screen and passing ¾ in.
155 lb. of Trinidad bitumen.

Analysis.

	Per Cent.
Bitumen (soluble) $C.S._2$	13·60
Passing 200 mesh	18·00
Passing 100 mesh	8·60
Passing 80 mesh	4·65
Passing 50 mesh	16·15
Passing 40 mesh	4·30
Passing 30 mesh	3·70
Passing 20 mesh	5·40
Passing 10 mesh	7·80
Retained 10 mesh	17·80
	100·00

Asphaltic macadam is now being so much used, and its component parts and mixing are getting to be so well understood that it would be superfluous, to some extent, to give more details in regard to it in this paper. The chief essentials to success in its use are, primarily, the character of the bitumen used, and the density (*i.e.*, freedom of voids) of the final mixture. If it were not for the extreme changeabilities of the English climate, it might be possible to adopt varying standards of asphaltic macadam for surfacing work in this country, but, as it is most essential to exercise the strictest carefulness in all such operations, each road must be considered in accordance with its requirements. Some standard compositions have been formed to withstand heavy traffic in the summer months, but they have failed completely in the more trying seasons of the year, and, especially so, during the severe climatic conditions which prevail in this country, from October to March, which have shown that the employment of low standards accounts greatly for the failures so frequently experienced. This important factor should not be lost sight of by those who are wishful to secure satisfactory and lasting work.

In actual practice it has been found that fine sharp sand, in proper proportions, is one of the best materials that can be used as an aggregate in connection with pure bitumen, for road surfacing. Its use has now been well established, but care must be exercised to obtain suitable distributions of the sand over a range of meshes—say one-tenth of an inch to a hundredth in size. Such a distribution should secure the requisite density. Sands which contain impalpable matter, clay or organic impurities, should be avoided. Clayey matter adheres to the coarser sand particles, during the process of heating and drying, with the result that the subsequent coatings of bitumen are much depreciated in value. Angular quartz sand has been proved to be the most suitable aggregate, but there are local sands in various parts of England, Ireland, Scotland and Wales, from which typical gradings may be obtained.

With regard to the preparation of asphaltic macadam, it is important, and necessary, to obtain what is known as a suitable "filler." The function of the latter is to increase the density of the bitumen covering the sand particles used, and to close the finest voids. For this purpose Portland cement has proved itself to be the most effectual material, owing probably, to its inertness in combination with bitumen, and its specific gravity. The "filler" used in asphaltic compounds forms a great desideratum in connection with the life of the material, under traffic conditions, and its qualities call for the most careful consideration.

In departing from the time-honoured use of water-bound macadam (tar-painted each year) for which material there is still, and undoubtedly will be for many years, a great call, it is reasonable to consider the most suitable thing to adopt in order to meet and resist, the abrasions, stress and attrition of modern traffic. The latter is bound to increase on mechanical principles, and it is useful to consider in what way, and with what material, the more important roads of the country are to be maintained. The writer has given this matter much attention and has outlined herein his own procedure, and experiments in regard to "asphaltic macadam."